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Polytechnic Institute of New York University
Brooklyn, NY 11201 -3840

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14. ABSTRACT
The Nanoelectronic Devices for Defense & Security (NANO-DDS) Conference is a biannual science and technology event which has been organized for the purpose of reviewing the evolving research and development (R&D) activities in the arena of nanoelectronic devices that have direct relevance to critical capability needs for national defense & security in the future. The charter of this special conference is to unify and focus the very broad array of nanoelectronic and supporting nanotechnology activities that are currently engaged in reaching the long expected applications payoffs in core defense and security related areas such as sensing, data processing

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a. REPORT	b. ABSTRACT	c. THIS PAGE			Erich Kunhardt
UU	UU	UU	UU		19b. TELEPHONE NUMBER 718-260-3172

Report Title

Final - 2011 Nanoelectronic Devices for Defense & Security

ABSTRACT

The Nanoelectronic Devices for Defense & Security (NANO-DDS) Conference is a biannual science and technology event which has been organized for the purpose of reviewing the evolving research and development (R&D) activities in the arena of nanoelectronic devices that have direct relevance to critical capability needs for national defense & security in the future. The charter of this special conference is to unify and focus the very broad array of nanoelectronic and supporting nanotechnology activities that are currently engaged in reaching the long expected applications payoffs in core defense and security related areas such as sensing, data processing, computation and communications. Here, the inherent multidisciplinary nature of the nanoscale science & technology (Nano-S&T) field and the potential for impacting high priority objectives motivate the unique organization of this conference.

Enter List of papers submitted or published that acknowledge ARO support from the start of the project to the date of this printing. List the papers, including journal references, in the following categories:

(a) Papers published in peer-reviewed journals (N/A for none)

Received Paper

TOTAL:

Number of Papers published in peer-reviewed journals:

(b) Papers published in non-peer-reviewed journals (N/A for none)

Received Paper

TOTAL:

Number of Papers published in non peer-reviewed journals:

(c) Presentations

Number of Presentations: 0.00

Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received Paper

TOTAL:

Number of Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received Paper

TOTAL:

Number of Peer-Reviewed Conference Proceeding publications (other than abstracts):

(d) Manuscripts

Received Paper

TOTAL:

Number of Manuscripts:

Books

Received Book

TOTAL:

Received Book Chapter

TOTAL:

Patents Submitted

Patents Awarded

Awards

Graduate Students

NAME	PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Names of Post Doctorates

NAME	PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Names of Faculty Supported

NAME	PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Names of Under Graduate students supported

NAME	PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Student Metrics

This section only applies to graduating undergraduates supported by this agreement in this reporting period

The number of undergraduates funded by this agreement who graduated during this period: .....

The number of undergraduates funded by this agreement who graduated during this period with a degree in science, mathematics, engineering, or technology fields:.....

The number of undergraduates funded by your agreement who graduated during this period and will continue to pursue a graduate or Ph.D. degree in science, mathematics, engineering, or technology fields:.....

Number of graduating undergraduates who achieved a 3.5 GPA to 4.0 (4.0 max scale):.....

Number of graduating undergraduates funded by a DoD funded Center of Excellence grant for Education, Research and Engineering:.....

The number of undergraduates funded by your agreement who graduated during this period and intend to work for the Department of Defense .....

The number of undergraduates funded by your agreement who graduated during this period and will receive scholarships or fellowships for further studies in science, mathematics, engineering or technology fields: .....

Names of Personnel receiving masters degrees

NAME

Total Number:

Names of personnel receiving PHDs

NAME

Total Number:

Names of other research staff

NAME	PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Sub Contractors (DD882)

Inventions (DD882)

Scientific Progress

N/A

Technology Transfer

2011 Nanoelectronic Devices for Defense & Security

August 29 to September 1

TECHNICAL PROGRAM & ABSTRACT DIGEST

for

2011 Nanoelectronic Devices for Defense & Security (NANO-DDS) Conference

29 Aug. – 1 Sept. | Brooklyn, New York

2011 NANO-DDS CONFERENCE THEME:

Present & Future Roles of Nanotechnology in the Forensic Sciences

Organized by:
U.S. Army Criminal Investigation Laboratory
U.S. Army Edgewood Chemical Biological Center (ECBC)
& U.S. Army Research Office (ARO)

Hosted by:
Polytechnic Institute of New York University

Maj. Gen. Wells has generously agreed to assume the role of lead-off Keynote Speaker as Maj. Gen. Justice became unavailable due to the development of a late scheduling conflict.

Major General Jimmie Jaye Wells
Commanding General
75th Mission Command Training Division

Major General Jimmie Jaye Wells was assigned as commanding general of the 75th Mission Command Training Division, Houston, Texas in July 2011. Prior to this assignment, he served as the Commander of the Civil Support Command, Kaiserslautern, Germany and Deputy Commanding General of the 21st Theater Sustainment Command. He previously served as the Commander of the 1st Battle Command Training Brigade, 75th Mission Command Training Division. He graduated with honors and was commissioned a Second Lieutenant from Officer Candidate School, Fort Benning, GA in 1981. He graduated with honors from the Defense Language Institute, Monterey, CA in 1982. His military education includes the Field Artillery Officer Basic and Advance courses; Korean Ranger Course; Infantry, and Ordnance Qualification courses; U.S. Air Force Load Planners Course, Jungle Warfare Course–Panama (twice), Basic Airborne Course and the 82nd Airborne Division Jumpmaster Course. He is a graduate of the Command and General Staff Officers Course, the Associate Logistics Executive Development Course, CAPSTONE Flag Officer Course, and Advanced Joint Professional Military Education. He earned a Masters of Business Administration from Golden Gate University- San Francisco in 1986 and a Masters of Strategic Studies at the Army War College in 2005. As a First Lieutenant, he served as a team leader for a nuclear support team and as the Operations and Intelligence Officer of the Weapons Support Detachment–Korea in 1982-83. He then became a Fire Support Officer for the 2nd Battalion, 505th Infantry, 82nd Airborne Division Artillery participating in Operation Urgent Fury, Grenada, in 1983. In 1988, he joined the 108th Division and served as an Infantry Company Commander. In 1992, he joined the 90th Regional Support Command in the Office of the Deputy Commander–Operations. He then became the Maintenance Operations Officer and later Executive Officer of 694th Maintenance Battalion for three years. He left that position to become the first commander of the 363rd Quartermaster Battalion (Petroleum) in 2000. In 2003, he returned to a second battalion command of the 694th Maintenance Battalion. He was subsequently selected as the Intelligence and Operations Officer and later as the Support Operations Officer for the 172nd Corps Support Group at Logistics Support Area Anaconda, Iraq. In his third combat tour, he was deputy for operations at the Iraq Reconstruction Management Office, U.S. Embassy in Baghdad. In October 2005, while still in Iraq, he was selected to command the newly formed 208th Regional Support Group and served a total of 22 months in theater. His awards and decorations include the Legion of Merit with two oak leaf clusters, Bronze Star with oak leaf cluster, Meritorious Service Medal with two oak leaf clusters, Army Commendation Medal with three oak leaf clusters, Combat Action Badge and the Master Parachutist Badge.

INTRODUCTION

Conference Theme

The **Nanoelectronic Devices for Defense & Security (NANO-DDS) Conference** is a bi-annual science and technology event which has been organized for the purpose of reviewing the evolving research and development (R&D) activities in the arena of nanoelectronic devices that have direct relevance to critical capability needs for national defense & security in the future. The charter of this special conference is to unify and focus the very broad array of **nanoelectronic and supporting nanotechnology activities** that are currently engaged in reaching the long expected applications payoffs in core defense and security related areas such as sensing, data processing, computation and communications. Here, the inherent multidisciplinary nature of the nanoscale science & technology (Nano-S&T) field and the potential for impacting high priority objectives motivate the unique organization of this conference.

The NANO-DDS Conference has a well-established tradition of being organizing around an applications-oriented framework that will allow for capturing the important science and technology (S&T) challenges to realizing the next generation in nanoelectronic devices, while at the same time being strongly inclusive to a host of innovative solutions that are continually evolving from the highly multidisciplinary areas of **nanoscience, nanomaterials, nanofabrication, nanoengineering and nanomedicine**. To this important end, the 2011 meeting will built around the theme of:

Present & Future Roles of Nanotechnology in the Forensic Sciences

Conference Sponsorship

The organizers of the 2011 NANO-DDS Conference would like to recognize the following major sponsors of the conference for their important support and contributions.

U.S.
National Science Foundation
Arlington, VA

U.S. Army
Edgewood Chemical Biological Center
RDECOM, Aberdeen Proving Ground, MD

U.S.
Army Research Laboratory
Durham, NC

U.S.
Defense Advanced Research Project Agency
Arlington, VA

U.S.
Army Research Office
Durham, NC

U.S.
Office of Naval Research
Arlington, VA

U.S.
Defense Threat Reduction Agency
Fort Belvoir, VA

U.S.
Air Force Office of Scientific Research
Arlington, VA

CONFERENCE SCOPE

Technical Focus

The unique focus of the NANO-DDS Conference is motivated because the R&D community that is actively fueling the important advances in nanoelectronic devices and systems presently spans many scientific and engineering disciplines and is often segmented into groups at the far ends of what can be defined as an applications spectrum. Specifically, one segment of the R&D community works mostly at the highly-applied end of the spectrum where nanoelectronic devices are being implemented to enhance and extend existing technological capabilities. Another segment of the R&D community works mostly at the frontier end of the spectrum where novel nanoelectronic devices are being conceptualized and investigated for their potential merits in defining entirely new technological capabilities. Therefore, the NANO-DDS Conference seeks to establish a formal academic forum for bridging the intellectual gap between the frontier and applications portions of the nanoelectronic devices spectrum for the purpose of accelerating nanotechnology payoffs that have relevance to national defense and security.

Nanoscale science and technology (Nano-S&T) have emerged over the last decade as important and highly visible components of nearly all scientific and engineering disciplines. This rapid growth in Nano-S&T activities has been motivated in large part by the fantastic and seemingly unlimited possibilities for advancing the state-of-the-art through the leveraging of fundamental mechanisms at the nanoscale and molecular levels through a progressively increasing ability to understand, prescribe and control all the basic properties (structural, chemical, mechanical, electronic and photonic) of ultra-small devices and systems. In addition, since Nano-S&T intrinsically represents an underlying blueprint and cross-cutting enabler to all disciplines, it permeates all the fundamental physical sciences and dictates the ultimate limits of nearly all engineering endeavors.

It is important to recognize that one of the strongest and most identifiable links of Nano-S&T to our modern society is through its recent impact on semiconductor-based consumer electronics — i.e., the continued down-scaling of Silicon-based computing and communication components and systems. While these advances are extremely important in their own right, the longer-term view of nanoelectronics is much more grandiose — i.e., the expectation is for completely new types electronic/photonic-based devices and architectures with revolutionary and/or disruptive technological capabilities. Both the continued down-scaling of conventional semiconductor electronics and the next-generation electronics (i.e., that some might call molecular-based electronics), rely heavily on a broad array of Nano-S&T investigations that span such areas as: biology, chemistry, physics, material science, along with engineering sciences such as electronics and mechanics, and even the computer sciences. By their very nature, all these multidisciplinary Nano-S&T efforts must concern themselves with molecular-level processes, and therefore must incorporate methodologies for interfacing to the microscopic phenomenon. As such, almost all the foundation work for the next-generation of nanoelectronics is intrinsically defining new sensor modalities, while at the same time it is contributing to the advancement of the

traditional capabilities (data & signal processing, computation and communication) needed for the realization of intelligent sensors and integrated multi-functional sensor systems.

This conference focuses on research and development (R&D) from the areas of **nanoscience**, **nanomaterials**, **nanofabrication**, **nanoengineering** and **nanomedicne** that are collectively building intellectual and technological bridges from nanoscale concepts to practical nanoelectronic devices and systems. More specifically, the conference seeks to provide a special academic forum for promoting interactions and information exchanges between leading scientists and technologists for the purpose of creating a unique nanoelectronic knowledge base and technology roadmap. The expected payoffs are an acceleration of the progress towards futuristic nanoscale devices and systems that possess new modalities, significantly enhanced effectiveness and integrated functionality (e.g., data processing, computation and communications) useful in defense and security relevance applications Long term expected payoffs include, but are not limited to, the sensing and monitoring of chemical, biological, radiological and nuclear threats so as to improve the survivability of soldiers on the battlefield and innocent civilians in the international community.

Technical Program

The 2011 NANO-DDS Conference has a lead-off theme-day that is focused on the subject of Nanoscale Science & Technology for Forensics. Here the technical program has been constructed from technical presentations that illustrate the major nanoscale S&T challenges and opportunities in the major subcategories of: (i) Legacy Forensic Sciences; (ii) Forensics Enabled Intelligence; and, (iii) Forensic Investigations in Cultural Heritage, Anthropology and Disaster Victim Identification. This overarching subject matter is then be followed by technical sessions that broadly survey the traditional nanoelectronic technical blocks of: (i) Sensor & System Applications; (ii) Device Concepts & Sensor/System Functionality; and (iii) Materials, Fabrication and Integration for Sensor/System Architectures. Hence, all combined this conference program will comprehensively encompass the challenges, opportunities and emerging S&T of relevance to nanoscale techniques and technologies of the future. Summarized, the conference covers the four technical area blocks as listed below:

I. Science & Technology for Forensics

II. Sensor & System Applications

II. Device Concepts & Sensor Functionality

III. Materials, Fabrication and Integration for Sensor Architectures

More specifically, R&D from the forensic sciences, nanoelectronic and supporting nanotechnology activities (e.g., nanoscience, nanomaterials, nanofabrication nanoengineering, nanomedicine) which possess strong relevance to core defense and security areas such as sensing, data processing, computation and communications were prioritized & organized into session areas as defined in the Summary Agenda section.

CONFERENCE ORGANIZATION

Program Committee

The **2011 Nanoelectronic Devices for Defense & Security (NANO-DDS) Conference** has been organized as an official technical-information gathering activity for use in advancing the state-of-the-art for the benefit of the U.S. Warfighter and U.S. Homeland Defense. To this end, the organizational process has been guided by the following Program Committee of government officials and those familiar with defense and security issues, and the underlying science and technology issues.

Symposium Chair

Dr. Jeff Salyards
U.S. Army Criminal Investigation Laboratory

Conference Theme Co-Chairs

Dr. Niamh Nic Daeid
The University of Strathclyde
Glasgow, Scotland

Dr. Jose R. Almirall
Florida International University
United States

Dr. Sue Black
University of Dundee
United Kingdom

Steering Committee Co-Chairs

Dr. James Jensen
U.S. Army ECBC

Dr. Robert Trew
U.S. National Science Foundation

Organizing Committee Co-Chairs

Dr. Dwight Woolard
U.S. Army Research Office

Dr. Dennis Polla
U.S. Defense Advanced Research Project Agency

Dr. Daniel Herr
Semiconductor Research Corporation

Dr. Babak Nikoobakht
U.S. National Institute of Standards & Technology

Technical Committee Co-Chairs

Dr. Madan Dubey
U.S. Army Research Laboratory

Dr. Gernot Pomrenke
U.S. Air Force Office of Scientific Research

Dr. Chagaan Baatar
U.S. Office of Naval Research

Dr. Meyya Meyyappan
U.S. NASA Ames Research Center

Publications Co-Chairs

Dr. Dwight Woolard
U.S. Army Research Office

Dr. Niamh Nic Daeid
Editor-in-Chief Science & Justice Journal

Liaison to Polytechnic Institute of New York University (NYU-Poly)

Prof. Erich Kunhardt
Department of Applied Physics, NYU-Poly

Liaison to the U.S. Military

LTC Clark Frederick
U.S. Army Research Office

Awards Co-Chairs

Dr. Christian Whitchurch
U.S. Defense Threat Reduction Agency

Dr. Shashi Karna
U.S. Army Research Laboratory

Dr. Richard Hammond
U.S. Army Research Office

Dr. John Zavada
U.S. National Science Foundation

Conference Manager

Dr. Greg Recine
Fordham University

Director of Technical Support

Prof. Anderson Chen
Stevens Institute of Technology

Special recognition and thanks go to:

Ms. Peggy Lacewell
U.S. Army Research Office

Dr. Greg Recine
Fordham University

Dr. Hal Grubin
University of Connecticut

Dr. Carl Tripp
University of Maine

for organization and implementation of funding that was used to support a significant number of student and senior attendees from many diverse groups and institutions.

2011 International Advisory Committee

The 2011 NANO-DDS Conference utilized the following list of leading technical experts from the international community to increase the technical merit & participation diversity of the meeting in regards to technical content and international participation.

Dr. Niamh Nic Daeid
Department of Pure and Applied Chemistry
The University of Strathclyde, Scotland

Dr./Prof. Ignacio Del Villar Fernandez
Department of Electrical & Electronic Engineering
Public University of Navarra, Spain

Dr. Alexandre Carella
CEA Grenoble Liten/DTNM/LCRE
France

Dr. Jackie Y. Ying
Institute of Bioengineering & Nanotechnology
Singapore

Prof. Otto S. Wolfbeis
Institute of Analytical Chemistry
University of Regensburg, Germany

Prof. Hiroshi Sugiyama
Department of Chemistry
Kyoto University, Japan

Prof. Osvaldo Novais de Oliveira Jr.
Institute of Physics of São Carlos
University of São Paulo, Brazil

Dr. Kris Iniewski
Redlen Technologies
Canada

Dr. Leskey M. Cele
Chemistry Department
Tshwane University of Technology
South Africa

Prof. Suprakas Sinha Ray
DST/CSIR Nanotechnology Innovation Centre
National Centre for Nanostructured Materials
South Africa

Prof. Avinash C Pandey
Nanotechnology Application Centre
University of Allahabad, India

Prof. Ashwini Kumar Srivastava
Chemistry Department
University of Mumbai, India

Prof. Sue Black
Centre for Anatomy & Human Identification
University of Dundee, United Kingdom

Dr. Amal Kasry
Egypt Nanotechnology Research Center
Smart Village, Cairo, Egypt

Dr. Muhammad Mustafa Hussain
Electrical Engineering
King Abdullah University
of Science and Technology
Kingdom of Saudi Arabia

Dr. Lian-Mao Peng
Key Laboratory for the Physics
and Chemistry of Nanodevices
Department of Electronics
Peking University, China

Dr. Kyungho Park
Director for Micro-System Programs
U.S. Army RDECOM
Int. Technology Center, Pacific (ITC-PAC)
Japan

Prof. Ioanna Kakoulli
Department of Material Science & Engineering
UCLA
UCLA/Getty Conservation Program
Director Archaeomaterials

Technical Guidance Committee

The following key technical experts have provided invaluable advice and support to the conference program committee, either during 2011 or in regards to prior years.

Paul Amirtharaj	**U.S. Army Research Laboratory, Adelphi**
John Anderson	**U.S. Army ERDC, Alexandria**
Masakazu Aono	**Osaka University, Japan**
Supriyo Bandyopadhyay	**Virginia Commonwealth University**
Charles Black	**IBM T. J. Watson Rsearch Center**
Peter Haring Bolivar	**University of Siegen, Germany**
Angela Belcher	**Massachusetts Institute of Technology**
Elliott Brown	**University of California, Santa Barbara**
Steven Brueck	**University of New Mexico**
Peter Burke	**University of California, Irvine**
Ralph Cavin	**Semiconductor Research Corporation**
John Carruthers	**Portland State University**
Wonbong Choi	**Florida International University**
Stephen Chou	**Princeton University**
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Jay Eversole	**U.S. Naval Research Laboratory**
Christopher Ezelle	**(Anteon) Langley Air Force Base**
Eric Forsythe	**U.S. Army Research Laboratory**

Jose Fortes	**University of Florida**
Stephen Goodnick	**Arizona State University**
Boris Gelmont	**University of Virginia**
Chris Grein	**University of Illinois, Chicago**
Donhee Ham	**Harvard University**
Majeed Hayat	**University of New Mexico**
Bryan Horner	**U.S. Defense Threat Reduction Agency**
James Hutchby	**Semiconductor Research Corporation**
David Janes	**Purdue University**
Janet Jensen	**U.S. Army ECBC**
Ioanna Kakoulli	**UCLA**
Shashi Karna	**U.S. Army Research Laboratory, APG**
Richard Kiehl	**University of Minnesota**
Stephen Kilpatrick	**U.S. Army Research Laboratory, Adephi**
Laszlo Kish	**Texas A&M University**
James Klemic	**MITRE Corporation**
Margarett Kosal	**U.S. Defense Threat Reduction Agency**
John Kosinski	**U.S. Army CECOM I2WD**
Meng Lean	**Palo Alto Research Center**
Jean-Pierre Leburton	**University of Illinois, Urbana-Champaign**
Philip LeDuc	**Carnegie Mellon University**
Stephen Lee	**U.S. Army Research Office**
Xiaolin Lei	**Shanghai Jiao Tong University, China**
Chenzhong Li	**Florida International University**
William Loerop	**U.S. Army ECBC**

Paolo Lugli	**Technicas University of Munich, Germany**
Mark Lundstrom	**Purdue University**
Yi Luo	**Carnegie Mellon University**
Scott Manalis	**Massachusetts Institute of Technology**
Paul Malchow	**National Science Foundation**
William Marinelli	**Physical Sciences, Inc.**
Robert McMillan	**U.S. Army Space & Missile Defense Com.**
June Medford	**Colorado State University**
Angela Mielke	**Los Alamos National Lab.**
John W. Mintmire	**Oklahoma State University**
Dan Morse	**University of California, Santa Barbara**
James Murday	**University of Southern California**
Pinaki Muzumder	**University of Michigan**
Babak Nikoobakht	**National Institute of Standards & Technology**
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Colin Nuckolls	**Columbia University**
Robert Opila	**University of Delaware**
Dev Palmer	**U.S. Army Research Office**
Ravindra Pandey	**Michigan Technological University**
Barrett Parker	**U.S. MANSCEN, Ft. Leonard Wood**
Jerry Pate	**U.S. Defense Threat Reduction Agency**
Richard Paur	**U.S. Army Research Office**
Thomas Pearl	**North Carolina State University**
Barry Perlman	**U.S. Army CERDEC**

Eric Pop	**University of Illinois, Urbana Champaign**
James Ratches	**U.S. Army CECOM NVESD**
G. Ramanath	**Rensselaer Polytechnic Institute**
Mark Reed	**Yale University**
Greg Recine	**Fordham University**
Alex Rimberg	**Dartmouth College**
Brigitte Rolfe	**MITRE Corporation**
Mordechai Rothschild	**Massachusetts Institute of Technology**
Thomas Schenkel	**Lawrence Berkeley Nat. Lab.**
Nadrian Seeman	**New York University**
Jorge Seminario	**Texas A&M University**
Sameer Singhal	**CRD Research Corporation**
Alexander Sinitskii	**University of Nebraska, Lincoln**
Clint Smith	**U.S. Army ERDC, Alexandria**
Sharon Smith	**Lockheed Martin Corporation**
Michael Stroscio	**University of Illinois, Chicago**
B. Swaminathan	**U.S. Army RDECOM ARDEC**
Nongjian Tao	**Arizona State University**
James Tour	**Rice University**
Elias Towe	**Carnegie Mellon University**
Robert Trew	**North Carolina State University**
Carl Tripp	**University of Maine**
Usha Varshney	**National Science Foundation**
R. Venkatasubramamian	**Research Triangle Institute**

David Walt	**Tufts University**
Donna Wang	**Michigan State University**
Lan Wang	**Washington University**
Peggy C. Wang	**Florida International University**
Christian Whitchurch	**U.S. Defense Threat Reduction Agency**
Alma Wickenden	**U.S. Army Research Laboratory, Adelphi**
Ngai Wong	**U.S. Defense Threat Reduction Agency**
Tommy Wong	**U.S. Army International Technology Center, Pacific**
John Yeow	**University of Waterloo, Canada**
John Zavada	**U.S. National Science Foundation**
Victor Zhirnov	**Semiconductor Research Corporation**

GENERAL INFORMATION

On-Site Registration

The registration desk (located at the Main Hall) will be open daily as follows,

Sunday, August 28:	**1:00 pm to 3:00 pm**
Monday, August 29:	**7:00 am to 5:00 pm**
Tuesday, August 30:	**7:00 am to 5:00 pm**
Wednesday, August 31:	**7:00 am to 1:00 pm**
Thursday, September 1:	**7:00 am to 12:00 Noon**

If you need emergency assistance please contact campus security.

Recommended Dress

Business casual dress (or military Class A or B uniform) is recommended for all conference functions.

The 2011 NANO-DDS Conference is UNCLASSIFIED

Attendees will include U.S. and foreign government (military and civilian), academia and industry representatives. All published materials have been documented as public domain, and authors should only present information that has been cleared for public release. An electronic version of this Technical Program & Abstract Digest can be obtained from the conference website – attendees interested in obtaining this document should contact the registration desk.

2011 NANO-DDS Conference Best-Paper Awards

All presented papers (oral and poster) will be considered for a 2011 NANO-DDS Conference Best-Paper Awards competition. Here, senior and student nominees will considered in each of the four block technical areas - i.e., **I. Science & Technology for Forensics; I. Sensor & System Applications; II. Device Concepts & Sensor/System Functionality; and, III. Materials, Fabrication & Integration for Sensor/System Applications**. In addition, senior and student nominees will considered from the poster session. All presentations (oral and poster) will be eligible for nomination by members of the 2011 Technical Program Committee and a formal evaluations procedure will be used by the Awards Chair and the technical area leaders to determine the final award winners. Here, the presentations will be judged on: (1) Scientific & Technical Merit, (2) Relevance to Defense & Security, and (2) Overall Quality of Public Presentation. Best-Paper award winners will receive plaques (mailed after the conference) and they will be recognized at the conference website.

Food & Refreshments

The conference provides **DAILY during the technical sessions**: a continental Breakfast (starting at 7 am) as well as morning and afternoon refreshments, as a part of the attendee registration fee.

The following social events are also included as a part of the registration fee:

Monday, August 29, 11:50 am to 1:00 pm: Conference Lunch
Keynote Speakers: Profs. Gregory & David Chudnovsky, NYU-Poly
Main Hall

Tuesday, August 30, 12:15 pm to 1:30 pm: Conference Lunch
Keynote Speaker: Dr. James Klemic, The MITRE Corporation
Main Hall

Tuesday, August 30, 6:30 pm to 8:30 pm: Poster Session (Social)
Hors d'ouevres, Soft Drinks
Main Hall

Wednesday, August 31, 12:15 pm to 1:10 pm: Conference Lunch
Keynote Speaker: Jadranka Travas-Sejdic, University of Auckland (New Zealand)
Main Hall

Conference Banquet

Wednesday, August 31, 7:00 pm to 10:00 pm: Conference Banquet*
Dinner Speaker: Dr. Harry Salem, U.S. Army Edgewood Chemical Biological Center
Subject: Molecular Engineering Opportunities in Stem Cell Research

*Attendees that purchased tickets online should pickup their tickets between 8:00 am and 12:00 Noon on Wednesday morning. Attendees without tickets should check at the registration desk during the period 1:30-2:00 pm on Wednesday afternoon to see if any seating is available.

Group Trip: American Museum of Natural History
Wednesday, August 31, 1:45 to 5:30 pm

A group trip to the American Museum of Natural History in Manhattan has been organized for Wednesday afternoon, August 31 from approximately 1:45 to 5:30 pm. Each registration packet should contain information regarding trip, along with subway directions to the museum. In addition, Dr. Greg Recine will organize a group for traveling there together, and if you would like to participate, please go to the Main Hall in 6 MetroTech between 1:30 and 1:45 pm. If you are interested in additional technical and/or logistic details please contact Dr. Recine by email (admin@nano-dds.com).

Sunday Technical Tutorials

The 2011 NANO-DDS Conference activities will also include the presentation of two technical tutorials on the Sunday afternoon (August 28) prior to the opening of regular conference events. These two technical tutorials are free (i.e., open to the general public that make arrangements for coming onto the NYU-Poly campus) and do not require any additional fees from conference attendees. Both of these tutorials are on subjects of very high relevance to the state-of-the-art in nanotechnology, and the Organizers of the 2011 Meeting are very appreciative to the tutorial lecturers for volunteering to given these very interesting and relevant topical discussions.

The location of both tutorials is the **Main Hall, 6 MetroTech, NYU-Poly Campus**, as is defined in the map in the Summary Agenda section of this digest.

First Tutorial: Artificial DNA to Support Nanotechnology

Time: 1:00 to 3:40 pm

Lecturers: Steven Benner,
Foundation for Applied Molecular Evolution, Gainesville FL &
Firebird Biomolecular Sciences LLC (www.ffame.org)

Michael Norton
Marshall University, Huntington, WV
(www.marshall.edu/mbic/atomcrafters/)

Summary - The ability of DNA molecules to assemble by themselves lies at the center of genetics. Further, because this self-assembly follows very simple rules (A pairs with T, G pairs with C), DNA appears to be the idea lplatform upon which to engineer self-assembling nanostructures. Indeed, one foundation of biology-related nanotechnology is found in the work of Ned Seeman, featured at the nanoelectronics conference, who constructed cubes and other assemblies from pieces of DNA using these simple rules. Following this vision, DNA today is used to form tiles that have two-dimensional assembly properties, folded structures ("origami") that begin with a large circular DNA molecules, DNA constructs that signal the outside world, and assemblies that perform simple computation and logical processes, among others. However, as nanotechnology based on DNA has developed, it has become clear that the DNA structure itself creates constraints and limitations. The structure of DNA was, after all, not created to be a platform for human engineering. Instead, it is the product of:

(a) constraints imposed by chemistry at the origin of life,
(b) adaptations to create a genetic molecule, and
(c) random events throughout the history of life on Earth.

For example, DNA suffers because one of its base pairs (AT) is weak, while the other (GC) is strong. This makes it difficult to get consistent and predictable assembly of DNA "biobricks". Years of frustration from attempts to assemble useful DNA nanostructures (not "gee whiz" toys) has driven a reengineering of DNA itself. The re-engineered artificial DNA is now empowering the design of nanostructures having capabilities far

beyond that is possible with natural DNA, and capabilities beyond those thought to be possible by those familiar with the behavior of natural DNA. It may shortly allow natural selection in the laboratory to pick up where design lethal in the construction of catalysts and receptors.

This tutorial will be fully interactive; *it will not be two hours of lectures*. Instead, at the outset, the preceptors will spend a few minutes presenting the new capabilities that re-engineered DNA deliver. These might include:

(i) Sensors based on self-assembled nanostructures
(ii) DNA diagnostics based on artifical genetic alphabets
(iii) Fluorescent signaling from nanostructure

The emphasis will *not* be on the chemistry behind re-engineered DNA, but rather on what it can do. The preceptors will then ask the audience for specific tasks and applications, to find out what kinds of nanodevices participants would like to have in hand. Then, the preceptors will lead an interactive discussion to explore what re-engineered DNA can for them to deliver the items on the "wish lists" of participants. Then, after a short break that permits participants to discuss among themselves and to consider options, the group will re-assemble to probe more deeply the potentials and limitations of artificial DNA in nanotechnology.

Second Tutorial: Graphene Electronics
Time: 4:00 to 5:00 pm

Lecturers: Chagaan Bataar, U.S. Office of Naval Research

Chagaan Baatar is a Program Officer at the Office of Naval Research in Arlington, Virginia, USA. He received his Ph.D. in condensed matter physics from University of Maryland in 1995. After postdoctoral appointments at MIT and IBM T. J. Watson Research Center, he was employed at Lucent Technologies Bell Laboratories as a Member of Technical Staff and worked on optical networking architecture design and optimization. Since 2003, Dr. Baatar has managed ONR's Nanometer Scale Electron Devices and Sensors program.

Summary - In the present tutorial, an overview of the properties and applications of Graphene will be given. The tutorial will be organized more or less chronologically in terms of the major developments, surveys of some of the representative papers in the literatures, with an eye toward electronics application. Other aspects such as mechanical, chemical and thermal properties will also be covered briefly. A rough outline follows:

1) Summary of salient physical properties of graphene.
2) Summary of leading graphene synthesis methods.
3) More in-depth and up-to-date review of current literature on electronic properties of graphene, e.g. bandgap, mobility, graphene nanoribbons and edge structures etc.
4) Summary of other interesting properties of graphene and other related materials.
5) Potential applications, e.g. transparent electrodes, nanoelectronics, optoelectronics, sensors, NEMS etc.

Notes

Summary of Major Technical Blocks & Session Areas

I. Nanoscale Science & Technology for Forensics

I(A) Legacy Forensic Sciences
I(B) Forensics Enabled Intelligence
I(C) Forensic Investigations in Cultural Heritage, Anthropology & Disaster Victim Identification

II. Sensor & System Applications

II(A) Analysis & Detection Methodologies for Threat-Agent Samples & Targets
II(B) Sensitivity & Discrimination Enhancement Mechanisms & Principles
II(C) Integrated & Networked Sensor Platforms & Infrastructure Technology
II(D) Imaging, Data Processing & Display Technologies

III. Device Concepts & Sensor/System Functionality

III(A1) Experimental Characterization & Theoretical Interpretation of Microenvironments
III(B1) Novel Signature Mechanisms & Recognition Techniques
III(C1) Nanostructure-Molecular Interface Science & Signal Transduction Phenomena

III(A2) Nano-Engineered Sources Detectors & Components for Situational Awareness
III(B2) Electrical & Photonic Properties of Coupled Nanostructure-Molecular Complexes
III(C2) Quantum-Effect Based Detection Modalities & Advanced Functionality

IV. Materials, Fabrication & Integration for Sensor/System Architectures

IV(A1) Engineered Nanoparticles for Enhanced Device & Sensor Functionality
IV(B1) Chemically-Directed/Selective Self-Assembly of Nanoscaffolds
IV(C1) Chemically-Synthesized & Biologically-Inspired Architectures

IV(A2) Construction & Application of 3-D Micro/Nano-Structures
IV(B2) Nanopatterning for Complex Systems
IV(C2) Hybrid Molecular & Nanoscale CMOS-Based Architectures

IV(S1) Graphene: Materials, Functionality & Novel Device Concepts
IV(S2) Nanolasers for Sensing

Session Focus Areas

I. Nanoscale Science & Technology for Forensics

I(A) Legacy Forensic Sciences
I(B) Forensics Enabled Intelligence
I(C) Forensic Investigations in Cultural Heritage, Anthropology and Disaster Victim Identification

Subject matter talks that collectively span the technical areas defined above will be presented within the set of Plenary Focus Sessions as listed below.

- **Forensic Science & Nanotechnology I**
- **Forensic Science & Nanotechnology II**
- **Forensic Science & Nanotechnology III**

II. Sensor & System Applications

II(A) Analysis & Detection Methodologies for Threat-Agent Samples & Targets

- **Nanoscale Technologies & Techniques I**
- **Nanoscale Technologies & Techniques II**

II(B) Sensitivity & Discrimination Enhancement Mechanisms & Principles

- **Nano-Enhanced Sensitivity**
- **Nano-Enhanced Discrimination**

II(C) Integrated & Networked Sensor Platforms & Infrastructure Technology

- **Sensor Platforms**
- **Architecture Design for Sensor Platforms**

II(D) Imaging, Data Processing & Display Technologies

- **Nano-Enabled Imaging Technology**

Session Focus Areas (Continued)

III. Device Concepts & Sensor/System Functionality

III(A1) Experimental Characterization & Theoretical Interpretation of Microenvironments

Micro-to-Nanoscale Characterization

III(B1) Novel Signature Mechanisms & Recognition Techniques

Spectral-Detection Based Techniques
Electro/Optical-Interaction Based Techniques
Nanomechanical Based Techniques

III(C1) Nanostructure-Molecular Interface Science & Signal Transduction Phenomena

Functionalized Organic-Inorganic Interfaces for Bio-Sensing

III(A2) Nano-Engineered Sources Detectors & Components for Situational Awareness

Nano-Electronics & Nano-Optics I
Nano-Electronics & Nano-Optics II
Bio-Nano Sensors

III(B2) Electrical & Photonic Properties of Coupled Nanostructure-Molecular Complexes

Molecular-Level Probes

III(C2) Quantum-Effect Based Detection Modalities & Advanced Functionality

Quantum-Driven Sensing

Session Focus Areas (Continued)

IV. Materials, Fabrication & Integration for Sensor/System Architectures

IV(A1) Engineered Nanoparticles for Enhanced Device & Sensor Functionality

Engineered Nanoparticles for Bio-Sensing Devices
Engineered Nanoparticles for Gas Sensing Devices
Engineered Nanoparticles – Properties

IV(B1) Chemically-Directed/Selective Self-Assembly of Nanoscaffolds

Control of Matter at the Nanoscale **Sensing at the Nanoscale**

IV(C1) Chemically-Synthesized & Biologically-Inspired Architectures

Nano-Architectures for Bio-Sensing

IV(A2) Construction & Application of 3-D Micro/Nano-Structures

Novel Micro/Nano Structures for Sensing

IV(B2) Nanopatterning for Complex Systems

NanoFabrication for Sensing & Monitoring

IV(C2) Hybrid Molecular & Nanoscale CMOS-Based Architectures

Low-Power Systems **New System Functionality**

IV(S1) Graphene: Materials, Functionality & Novel Device Concepts

Graphene Growth & Functionalization **Graphene Analysis & Characterization**
Graphene Device Fabrication & Optimization

IV(S2) Nanolasers for Sensing

Nanoscale Laser & Photonic Systems

2011 NANO-DDS CONFERENCE AGENDA MAP – Day 1

Monday	August 29
07:50 – 10:00	Keynote Sessions
07:50	Welcome: Prof. Kurt Becker, NYU-Poly; Introduction: Dr. Dwight Woolard, Army Research Office
08:00	Major General Nick Justice Commanding General U.S. Army Research, Development and Engineering Command and Aberdeen Proving Ground, MD
08:30	Dr. Jeff Salyards Director of Science & Technology U.S. Army Criminal Investigation Laboratory
09:00	Dr. Douglas Ubelaker Smithsonian Institution
09:30	Dr. Mark Griep U.S. Army Research Laboratory
10:00 – 10:20	Morning Break
10:20 – 11:50	I(A) Forensic Science & Nanotechnology I
12:10 – 13:00	Lunch Keynote Talk: Profs. Gregory & David Chudnovsky, Department of Mathematics, NYU-POLY
13:00 – 15:00	I(B) Forensic Science & Nanotechnology II
15:00 – 15:20	Afternoon Break
15:20 – 17:20	I(C) I(B) Forensic Science & Nanotechnology II
17:20 – 19:20	Dinner Break
19:20 – 21:00	Roundtable Discussion on "Legal, Medical and Cultural Ramifications of Molecular-Level Sensing" Chairs: Amal Kasry & Dwight Woolard

2011 NANO-DDS CONFERENCE AGENDA MAP – Day 2

Tuesday	August 30	Contributions from Technical Blocks II, III & IV		
08:00 – 08:25	Morning Plenary Talk: Prof. Zhong Lin Wang, Materials Science & Engineering, Georgia Tech			
08:40 – 10:05	II(A) Nanoscale Technologies & Techniques	II(C) Sensor Platforms	III(A2) Nano-Electronics & Nano-Optics I	IV(B1) Control of Matter at the Nanoscale
10:05 – 10:25	Morning Break			
10:25 – 12:10	II(A) Nanoscale Processes & Interactions	II(C) Architecture Design for Sensor Platforms	III(B2) Molecular-Level Probes	IV(A2) Novel Micro/Nano Structures for Sensing
12:15 – 13:30	Lunch Keynote Talk: Dr. James Klemic, MITRE Nanosystems Group, The MITRE Corporation			
13:30 – 13:55	Afternoon Plenary Talk: Prof. Nadrian Seeman, Department of Chemistry, New York University			
14:10 – 15:35	II(B) Nano-Enhanced Sensitivity	II(D) Nano-Enabled Imaging Technology	IV(B2) NanoFab for Sensing & Monitoring	IV(B1) Sensing at the Nanoscale
15:35 – 15:55	Afternoon Break			
15:55 – 17:45	II(B) Nano-Enhanced Discrimination	IV(S2) Nanoscale Laser & Photonic Systems	III(A1) Micro-to-Nanoscale Characterization	III(C1) Functionalized Organic-Inorganic Interfaces for Bio-Sensing
17:45 – 18:30	Dinner Break			
18:30 – 20:30	Poster Session			

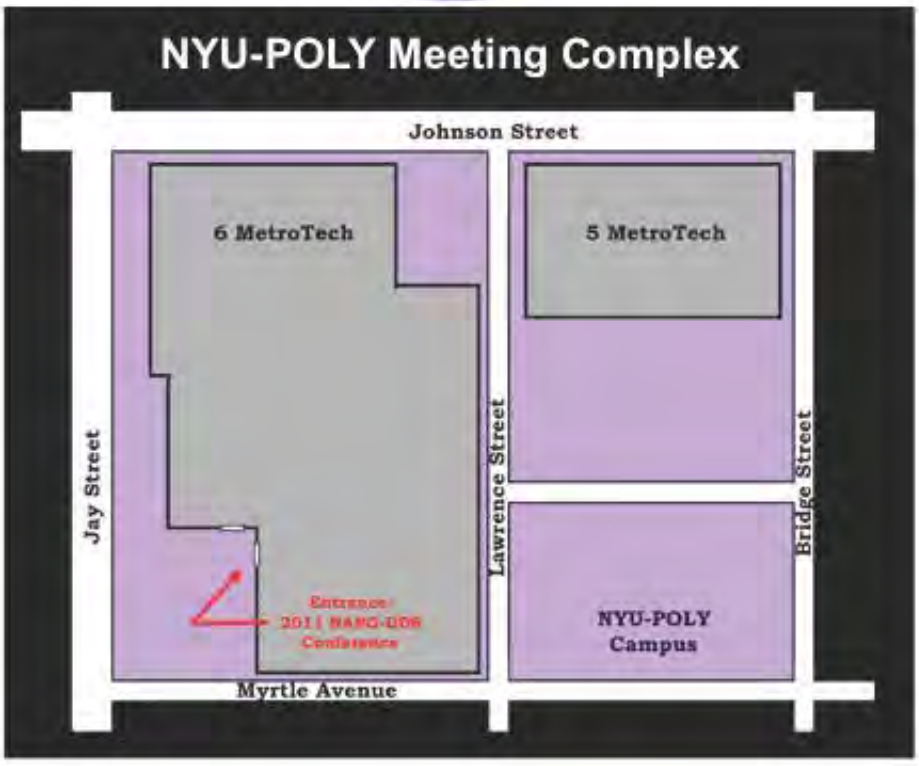
2011 NANO-DDS CONFERENCE AGENDA MAP – Day 3

Wednesday	August 31			
08:00 – 08:25	Morning Plenary Talk: Dr. Alexandre Carella, Nanomaterials Technologies Department, CEA (France)			
08:40 – 10:05	III(B1) Spectral-Detection Based Techniques	IV(C2) Low Power Systems	IV(A1) Engineered Nanoparticles - Properties	IV(S1) Graphene Growth & Functionalization
10:05 – 10:25	Morning Break			
10:25 – 12:10	III(B1) Electro/Optical-Interaction Based Techniques	IV(C2) New System Functionality	III(A2) Nano-Electronics & Nano-Optics II	III(C1) Optoelectronic Materials & Devices
12:15 – 13:30	Lunch Keynote Talk: Prof. Jadranka Travas-Sejdic, Department of Chemistry, University of Auckland (New Zealand)			
13:30	Free Afternoon			
13:45 – 17:30			Group Trip: American Museum of National History in Manhattan Meet in Main Hall, Ground Level of 6 Metrotech	
19:00 – 21:00	Conference Banquet Prospect Ballroom Sheraton Brooklyn New York Hotel 228 Duffield Street, Brooklyn, NY			

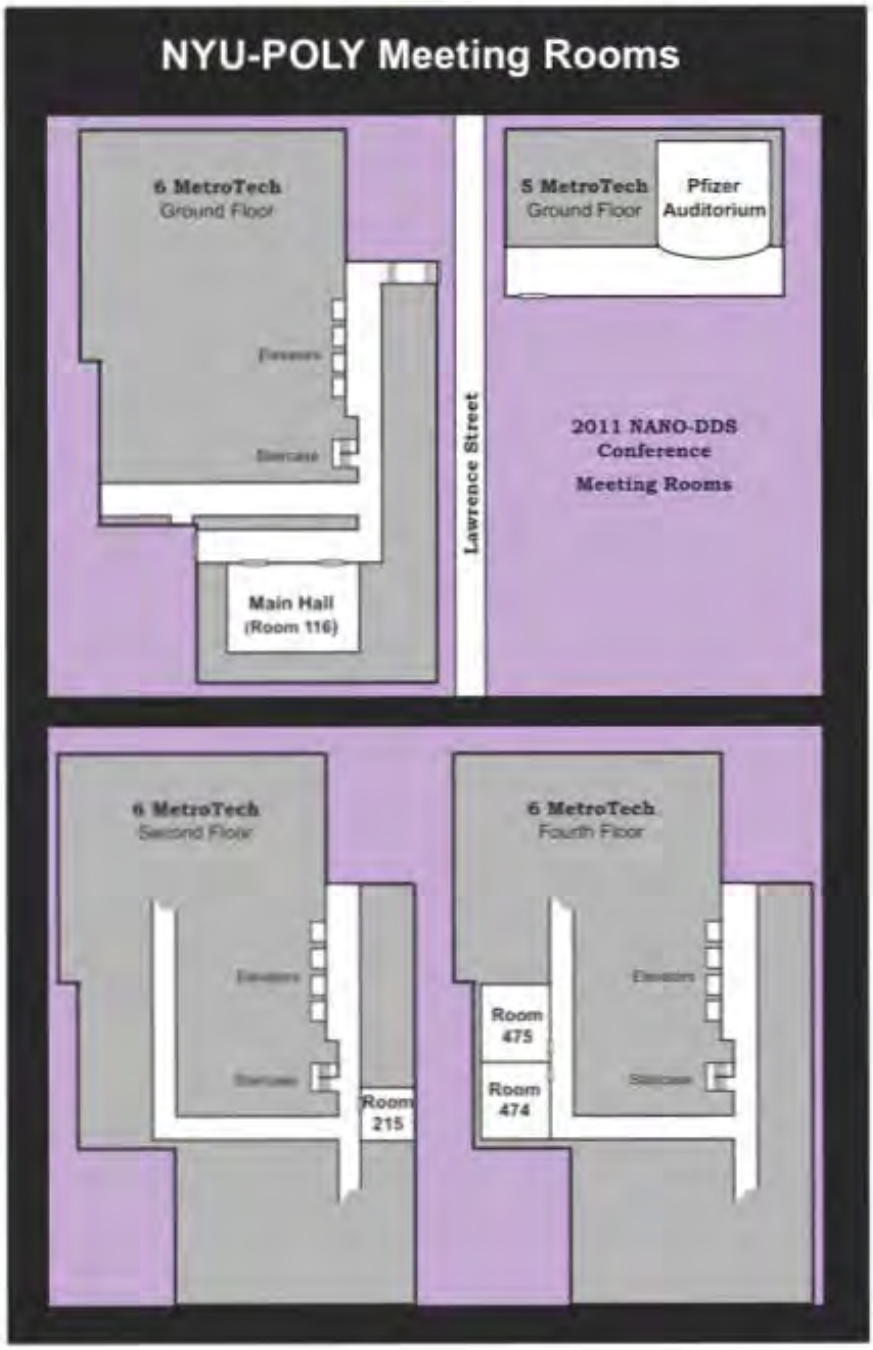
2011 NANO-DDS CONFERENCE AGENDA MAP – Day 4

Thursday	September 1	Contributions from Technical Blocks III & IV		
08:00 – 08:25	Morning Plenary Talk: Prof. Andrew Briggs, Department of Materials, Oxford University (UK)			
08:40 – 10:05	III(C2) Quantum-Driven Sensing	IV(C1) Nanoarchitectures for Bio-Sensing	IV(A1) Engineered Nanoparticles for Bio-Sensing Devices	IV(S1) Graphene Analysis & Characterization
10:05 – 10:25	Morning Break			
10:25 – 12:10	III(B1) Nanomechanical Based Techniques	III(A2) Bio-Nano Sensors	IV(A1) Engineered Nanoparticles for Gas Sensing Devices	IV(S1) Graphene Device Fabrication & Optimization
12:15	End of Conference			

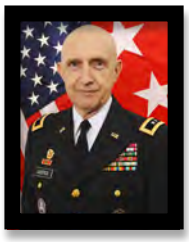
2011 NANO-DDS CONFERENCE MEETING SITE MAP



2011 NANO-DDS CONFERENCE MEETING SITE MAP



Keynote Session

Monday, Aug. 29	Location: Pfizer Auditorium
07:50	Welcome & Introduction **Prof. Kurt Becker** Associate Provost & Professor NYU-Poly **Dr. Dwight Woolard** Electronics Division U.S. Army Research Office
08:00	TECHNOLOGY & THE WARFIGHTER **Major Gen. Nick Justice** Commanding General U.S. Army Research, Development and Engineering Command Aberdeen Proving Ground, MD 
08:30	FORENSIC SCIENCE: FACT, FICTION & FUTURE NEEDS **Dr. Jeff Salyards** Chief Scientist US Army Criminal Investigation Laboratory 
09:00	TECHNOLOGICAL APPLICATIONS IN FORENSIC ANTHROPOLOGY **Dr. Douglas Ubelaker** Curator, Physical Anthropology Smithsonian Institution 
09:30	BIONANO-HYBRID ELECTRONICS FOR REAL-TIME TARGET SENSING **Dr. Mark Griep** National Research Council Associate Fellow U.S. Army Research Laboratory 
10:00 – 10:20	Morning Break: Pfizer Auditorium

Notes

TECHNICAL SESSIONS – MONDAY, August 29

Notes

Monday, August 29: 2011 NANO-DDS Conference: Room Assignment

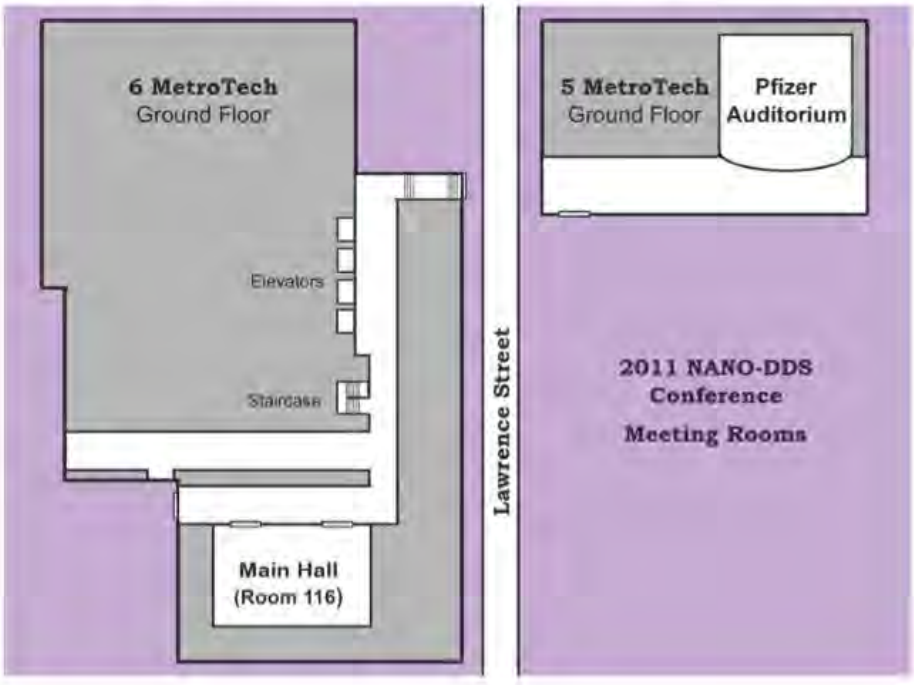
Time Schedule	Pfizer Auditorium
Breakfast*	
07:50 – 10:00	Keynote Session
Morning Break*	

Time Schedule	Pfizer Auditorium	Main Hall
10:20 – 11:50	I(A) Forensic Science & Nanotechnology I	
Lunch Break		★ Lunch Keynote Talk: Profs. Gregory & David Chudnovsky Department of Mathematics, NYU-POLY
13:00 – 15:00	I(B) Forensic Science & Nanotechnology II	
Afternoon Break*		
15:20 – 17:20	I(C) Forensic Science & Nanotechnology III	
Dinner Break		
20:00 – 21:00		Roundtable Discussion on "Legal, Medical and Cultural Ramifications of Molecular-Level Sensing" Chairs: Amal Kasry & Dwight Woolard

* Breakfast & Morning/Afternoon Break food & drinks will be served in front of the Pfizer Auditorium

★ Lunches will be provided in the Main Hall to all conference attendees

2011 NANO-DDS Conference Meeting Site Map



I. Nanoscale Science & Technology for Forensics

Monday, Aug. 29	Location: Pfizer Auditorium
I-A	Forensic Science & Nanotechnology I
	Chair: Jeff Salyards, US Army Criminal Investigation Laboratory
10:20-10:50	FORENSIC SCIENCE RESEARCH AT THE FBI LABORATORY
Plenary	Gene Peters, U.S. FBI Laboratory
10:50-11:20	SAMPLING AND PRECONCENTRATION OF VOLATILES FROM DRUGS AND EXPLOSIVES USING A NOVEL PLANAR SOLID PHASE MICROEXTRACTION (PSPME) GEOMETRY COUPLED TO ION MOBILITY SPECTROMETRY
Plenary	Jose Almirall, Florida International University
11:20-11:50	RAPID HUMAN DNA ANALYSIS FOR FIELD FORENSICS: ACCELERATED NUCLEAR DNA EQUIPMENT (ANDE)
Plenary	James Harper, MIT Lincoln Laboratory
11:50-13:00	LUNCH (see special presentation below)
	Location: Main Hall
12:10-12:40	CHALLENGES OF IN-CIRCUIT FUNCTIONAL TIMING TESTING OF SYSTEM-ON-A-CHIP
Lunch Keynote	Gregory & David Chudnovsky, Polytechnic Institute of NYU

I-A. Forensic Science & Nanotechnology I

FORENSIC SCIENCE RESEARCH AT THE FBI LABORATORY
Gene Peters
FBI Laboratory Counterterrorism and Forensic Science Research Unit

The FBI Laboratory Counterterrorism and Forensic Science Research Unit conducts applied research in support of its intelligence and law enforcement mission. Our goals are to provide new collection and analysis capabilities, improve existing methods, and contribute to admissibility defense. Our research portfolio spans all areas of forensic science: biological forensics with DNA and RNA; traditional chemical forensics with elemental analysis and toxicology; and pattern evidence. New areas with cross-cutting applications include provenance studies; human scent biometrics, and explosives intelligence. The FBI Laboratory Counterterrorism and Forensic Science Research Unit conducts applied research in support of its intelligence and law enforcement mission. Our goals are to provide new collection and analysis capabilities, improve existing methods, and contribute to admissibility defense. Our research portfolio spans all areas of forensic science: biological forensics with DNA and RNA; traditional chemical forensics with elemental analysis and toxicology; and pattern evidence. New areas with cross-cutting applications include provenance studies; human scent biometrics, and explosives intelligence.

SAMPLING AND PRECONCENTRATION OF VOLATILES FROM DRUGS AND EXPLOSIVES USING A NOVEL PLANAR SOLID PHASE MICROEXTRACTION (PSPME) GEOMETRY COUPLED TO ION MOBILITY SPECTROMETRY

Jose Almirall
Florida International University

Solid Phase MicroExtraction (SPME) has been proven as an effective sampling and preconcentration method for coupling with GC-MS for the analysis of a wide variety of matrices to detect a range of analytes of interest to environmental, pharmaceutical and forensic scientists. SPME has been successfully coupled to an ion mobility spectrometer (IMS) in our group as this combines the extraction efficiency of SPME and the detection capabilities of IMS and is easily adaptable to the more than 10,000 IMS instruments currently deployed at airports, checkpoints and other security locations requiring explosives/drugs detection. A novel planar SPME has been developed that allows vapor sampling in addition to particle sampling, affords the capability for the sampling of the explosives, when the vapor pressure of the explosives are sufficiently high and for the sampling and extraction of taggants and odor signatures of explosives, when the vapor pressure of the explosives is very low. This approach mimics the mechanism of biological detectors (canines) to associate and generalize the presence of odor compounds to the presence of an explosive or drug. A direct comparison between canine detection and the SPME-IMS detection of drugs (MDMA tablets) is reported for the first time. The PSPME geometry allows for direct insertion into existing IMS instruments without further modification. A glass or fused silica disk with a polymeric coating as a sorbent phase increases the surface the surface area and capacity of the extraction phase by more than 10,000X over the single SPME fiber currently in use.

RAPID HUMAN DNA ANALYSIS FOR FIELD FORENSICS: ACCELERATED NUCLEAR DNA EQUIPMENT (ANDE)

James Harper
MIT Lincoln Laboratory

Lunch Keynote Presentation

CHALLENGES OF IN-CIRCUIT FUNCTIONAL TIMING TESTING OF SYSTEM-ON-A-CHIP

David V. Chudnovsky, Gregory V. Chudnovsky
Polytechnic Institute of NYU

Complex hardware deeply imbedded in large-scale systems requires continuous testing and verification. These requirements are becoming more demanding in deep sub-micron and multi-billion gates logic, subjected to various sources of noise and disruption. Reliance on initial manufacturing testing, even on "at speed" testing is no longer adequate. Similarly, the existence of local LBIST engines for the purpose of discovering static faults often cannot protect against timing violations. This problem becomes more acute with very large die sizes, process variation contributing significantly to timing problems, and with the need to lower power consumption through various tricks, including voltage binning. The absence of comprehensive logic and timing verification built into large imbedded system leads to significant increase in debug time, and may contribute to project failures. We will describe some challenges here, and opportunities of anticipating these challenges in new design methodologies. Particular examples involve an in-circuit functional timing testing of systems with millions of cores.

I. Nanoscale Science & Technology for Forensics

Monday, Aug. 29	Location: Pfizer Auditorium
I-B	Forensic Science & Nanotechnology II
	Chair: Niamh Nic Daeid, University of Strathclyde, Scotland
13:00-13:30	USE OF STABLE ISOTOPE ANALYSIS IN FORENSIC SCIENCE
Plenary	Max Coleman, JPL/ California Institute of Technology
13:30-14:00	RECENT DEVELOPMENTS IN THE ANALYSIS OF SOIL AND DUST FOR FORENSIC INTELLIGENCE PURPOSES
Plenary	Kenneth Pye, Kenneth Pye Associates, LTD-UK
14:00-14:30	HYDRODYNAMIC FOCUSING FOR SENSNG AND MICRO/NANO-FABRICATION
Plenary	Frances Ligler, U.S. Naval Research Laboratory
14:30-15:00	DENATURATION MAPPING OF DNA IN NANOFLUIDIC CHANNELS: A NEW APPROACH TO SINGLE-MOLECULE DNA ANALYSIS
	Walter Reisner, McGill University, Canada
15:00-15:20	AFTERNOON BREAK: Pfizer Auditorium

I-B. Forensic Science & Nanotechnology II

USE OF STABLE ISOTOPE ANALYSES IN FORENSIC SCIENCE
Max Coleman
JPL, California Institute of Technology

Most of the chemical elements have atoms of more than one atomic weight; the nonradioactive ones are the stable isotopes. The ratios of the abundances of the minor isotopes to the major one (usually the lightest) vary very little in all materials to be considered. However, there are small but significant variations in such ratios of a few tenths of a percent. Measuring these ratios precisely (a few parts per million of the ratio) gives information on the origin of materials of forensic interest. For example, the hydrogen and oxygen isotopic compositions of ocean water are effectively constant, but those of rain and snow reflect the geographical location of the precipitation. This can be used to constrain the place of origin of manufactured substances, of plants and of people: the isotopic compositions of all of these may be related to local water which helps to form them. In the case of people, hair samples can record successive locations before illegal entry into a country. Stable isotope compositions of the light elements, H, C, N, O, S and Cl have been measured traditionally by mass spectrometry, but more recently tunable diode-laser infra-red spectrometry has proved a valuable alternative for a few specific molecular species. Forensic science problems attacked by this approach include comparison of bulk samples, comparison of bulk/trace and trace/trace samples, as well as determining the geographical origin of bulk or trace materials and authentication of documents. Explosives and drugs have been major targets but increasingly human provenancing and environmental forensics have gained prominence.

RECENT DEVELOPMENTS IN THE ANALYSIS OF
SOIL AND DUST FOR FORENSIC INTELLIGENCE PURPOSES

Kenneth Pye
Kenneth Pye Associates Ltd, Berkshire, UK

Studies in forensic geology have been conducted for more than a century but over the course of the past decade there have been major advances made both in investigative methodology and analytical techniques. Essentially there are two complementary approaches, one involving the examination of bulk properties of rocks, soils, sediments and dusts, and the other focusing on the properties of individual particles. Recent developments in analytical instrumentation have greatly increased the capacity to analyse and characterise small bulk samples and very small individual particles. Such techniques include solution-based inductively-coupled plasma mass spectrometry (ICP-MS) and inductively coupled plasma atomic emission spectroscopy (ICP-AES), laser ablation ICP-MS of solid particles, high resolution electron microscopy and microanalysis, and reflection nano-computer X-ray tomography. However, improved analytical capabilities have raised additional questions about compositional and textural variability at nano- through micro- to meso- and macro-scales, the selection of appropriate field and laboratory sampling protocols, inter-sample comparison procedures, the requirements for reference database information and methods of database interrogation. This presentation reviews recent research on these aspects undertaken in the UK, and provides illustrations of forensic intelligence applications.

HYDRODYNAMIC FOCUSING FOR SENSING AND MICRO/NANO-FABRICATION

Frances Ligler
U.S. Naval Research Laboratory

Flow in microfluidic channels is laminar, i.e. streams flow in parallel without mixing. This absence of convection has both facilitated and frustrated the development of lab-on-a-chip systems. A plethora of publications describe mixers designed to overcome laminar flow limitations at low Reynolds numbers. The development of simple mixing structures in the microchannel walls started my lab on path to design microfluidic structures for a wide variety of applications including sensors and microflow cytometers. We use hydrodynamic focusing of one laminar stream by another for separations, optical components, biosensors, cell analysis, and micromanufacturing. Applications include target focusing to the sensor surface, creating fluid "walls" to confine electrical fields, fabricating flow cytometers for detecting pathogens in nasal wash or identifying marine algae, and manufacturing polymers with predefined cross-sectional shapes and internal molecular alignment. New contributions to general utilization of hydrodynamic focusing include an example of inertia at Reynolds numbers between 1 and 10 (where it is not supposed to exist), reversal of hydrodynamic focusing to recycle sheath fluid in the flow cytometer, and micromaterials with structures defined at multiple length scales (nm, μm, mm, cm).

DENATURATION MAPPING OF DNA IN NANOFLUIDIC CHANNELS:
A NEW APPROACH TO SINGLE-MOLECULE DNA ANALYSIS

Walter Reisner
McGill University-Canada

Nanochannel based DNA stretching can serve as a platform for a new optical mapping technique based on measuring the pattern of partial melting along extended DNA molecules. We partially melt DNA extended in nanofluidic channels via a combination of local heating and added chemical denaturants. The melted molecules exhibit a non-uniform fluorescence profile corresponding to a series of local dips and peaks in the intensity trace along the stretched molecule. We show that this barcode is consistent with the presence of locally melted regions along the molecule and can be explained by calculations of sequence-dependent melting probability (W. Reisner, N. B. Larsen, A. Kristensen, J. Tegenfeldt & H. Flyvbjerg. PNAS 107, 13294-13299 (2010): featured as highlighted research in Nature Methods, Sept 2010). In addition, we demonstrate that the melting profile can be used to align a BAC sequence to its correct position on chromosome 12. The strength of the technique is that it can obtain sequence information for single molecules on a purely physical basis with no need for specific enzymatic labeling or digestion. In particular, the ability to identify the genomic location of DNA fragments on a single molecule basis could be critical to developing future technologies for long-range genomic and epigenetic mapping of single-cells.

I. Nanoscale Science & Technology for Forensics

Monday, Aug. 29	Location: Pfizer Auditorium
I-C	Forensic Science & Nanotechnology III
	Chair: Sue Black, University of Dundee-UK
15:20-15:50	MOLECULAR AND NANOSCIENCE IN PALEOFORENSICS AND MODERN CRIMINAL INVESTIGATIONS
Plenary	Ioanna Kakoulli, UCLA/ Cotsen Institute of Archaeology
15:50-16:20	ANALYSIS OF MODERN AND CONTEMPORARY ART: WHAT WE KNOW AND WHAT WE WANT TO KNOW
Plenary	Narayan Khandekar, Harvard Art Museums
16:20-16:50	RECENT ADVANCES IN THE APPLICATION OF SURFACE-ENHANCED RESONANCE RAMAN SCATTERING TO ART AND FORENSIC ANALYSIS
Plenary	Marco Leona, The Metropolitan Museum of Art-NYC
16:50-17:20	BASELINE STUDIES FOR A PROBABILISTIC APPROACH TO GEOGRAPHICAL ORIGIN INTELLIGENCE
Plenary	Jurian Hoogewerff, Oritain Global Ltd-NZ
17:20	Dinner Break

I-C. Forensic Science & Technology III

MOLECULAR AND NANOSCIENCE IN PALEOFORENSICS
AND MODERN CRIMINAL INVESTIGATIONS
Ioanna Kakoulli
UCLA-Getty Conservation Program/Cotsen Institute of Archaeology

Nanoscience and nanotechnology has received impetus in the last decades with advancements in technology that revolutionized and transformed the way we understand the physical world around us. In geo-bio-anthropology and forensic archaeology nanoscience and nanotechnology have contributed in two distinctive ways: (1) by revealing technological and/or bio-molecular markers essential to classify, authenticate and preserve cultural materials by enabling the visualization of materials at sub-micron scales and with chemical measurements at trace quantities (2) with the development of improved and new technology, tools and methods that have increased exponentially the portability and sensitivity of current instrumentation and provided the means for in situ non-destructive faster, more reliable, reproducible and robust measurements of very delicate materials of archaeological, historic and artistic value.

ANALYSIS OF MODERN AND CONTEMPORARY ART:
WHAT WE KNOW AND WHAT WE WANT TO KNOW

Narayan Khandekar
Harvard Art Museums

The analysis of modern and contemporary art presents new challenges when compared to older works of art. A wide variety of materials is at the artist's disposal, some of it artist oriented, some of it household materials and some industrially produced. Determining the origin of material when faced with this range is daunting. Identifying pigment particles presents a challenge, as these are often less than one micron in size and colored by complex synthetic molecules. Transparent coatings can come from a variety of sources, and in fact many works are not varnished at all. Analysis is often instigated by the need to: explain changes that have occurred over time, such as fading or blanching; understand damages that have resulted from mishandling or inherent vice; assist conservators with conservation treatments when an work of art is required for exhibition; characterize the materials used by the artist; asses the attribution of a work of art. Techniques used for analysis are most commonly optical microscopy, FTIR, Raman Micro-spectrometry, GCMS and pyrolysis-GCMS; MALDI-TOF-MS and LDI-TOF-MS; and SEM-EDS. Case studies will be used to illustrate how the investigation of a work of art can explain various issues, but then raise a whole new set of questions.

RECENT ADVANCES IN THE APPLICATION OF SURFACE-ENHANCED RESONANCE RAMAN SCATTERING TO ART AND FORENSIC ANALYSIS

Marco Leona
Dept. of Scientific Research The Metropolitan Museum of Art-NYC

Works of art are complex assemblages of inorganic and organic materials, often with unknown histories. Many analytes of interest – markers for provenance, attribution, and use history - are present in very low concentrations and are often affected by degradation processes. Sampling limitations make chemical analysis of art a serious challenge for any technique. In recent years surface-enhanced resonance Raman scattering (SERRS) has been proposed as a valuable tool for the identification of organic colorants –an extremely important class of materials, used as textile dyes or pigments in artistic and decorative objects for millennia. The potential of the technique for microanalytical application has been amply demonstrated. Work conducted in our laboratory using resonant excitation, a monodisperse silver colloid produced by microwave supported reduction of silver sulphate with glucose and sodium citrate, and a lossless non-extractive hydrolysis sample treatment procedure has allowed us to document the earliest use of a madder lake pigment, the earliest known use of lac dye in European art, and several examples of kermes and cochineal glazes, and madder, cochineal, methyl violet, and eosine lakes, from Ancient Egypt to the Impressionists, using samples as small as 25 micrometers in diameter.

BASELINE STUDIES FOR A PROBABILISTIC APPROACH
TO GEOGRAPHICAL ORIGIN INTELLIGENCE

Jurian Hoogewerff, Clemens Reimann, Rob Posey, Russell Frew
Oritain Global Ltd-NZ, University of East Anglia-UK, NGU-Norway, University of Otago-NZ

There is an increasing demand for the ability to track and provenance natural products, manufactured goods and also humans. In the case of commercial goods like food products, claims of geographical origin need to be authenticated by new tools independent of the existing supply chain traceability information that can easily be falsified. In cases where materials are non-compliant with a stated origin, or simply of unknown origin, tools are required that attribute these to most likely source regions using a scientific measure of probability. A similar approach is required for forensic evidence materials that could help reconstruct a crime or provide intelligence in counter-terrorism or military pursuits. In theory the natural environment is spatially extremely diverse and provides a wealth of parameters that can be used to spatially classify distinct areas, e.g. pollen, dust and soil mineralogy. The main challenge is to accumulate enough data for an interesting parameter so that it can be used as a proper forensically validated control database. The latter is not only essential for provenancing unknowns but also critical in assessing random match probabilities in the simplest one to one comparisons. Any analysis in a comparison between pieces of evidence that result in the materials being analytically dissimilar still needs the control database to make any conclusions about factual inconsistency.

Roundtable Discussion:

Monday, Aug. 29	Location: Main Hall
19:30-21:00	LEGAL, MEDICAL AND CULTURAL RAMIFICATIONS OF MOLECULAR-LEVEL SENSING
	Chair: Amal Kasry, IBM & Dwight Woolard, ARO

As nanoscience and nanotechnology continues to advance and is applied for an ever increasing number of sensing applications, it is reasonable and perhaps prudent to ponder the “legal, medical and cultural” ramifications of the use of techniques and technologies that primarily reside and functional within the ultra-small regime. Please join us, and a small panel of legal experts from the New York City community, to engage in an open discussion on the potentially unexpected requirements and responsibilities for researchers engaged in molecular-level sensing when considered in the context of the law, medical ethics and cultural attitudes. Please bring an open mind, and some questions from your particular area of expertise and experience for what should prove to be an interesting and thought provoking discussion and opportunity for learning.

Example questions to be addressed may include:

What are the privacy issues and associated responsibilities when developing nanoscale sensor probes?

When a nanosensor is applied to detect or diagnose one property, but is capable of simultaneously gathering information regarding an array of other properties (e.g., human physiology), what are the associated disclosure issues and responsibilities?

When new nanosensors are being developed and tested that are perceived as safe from the perspective of a technical expert, what would be the reasonable expectation and standards (e.g., from the legal perspective) for understanding the limits of their effects?

When an international company designs a nanosensor, should the kind of rules to control the sensor capabilities or the way it is used be universal or should they vary from one country to the other according to the different cultures? laws? etc?

TECHNICAL SESSIONS – TUESDAY, August 30

Tuesday, August 30: 2011 NANO-DDS Conference: Room Assignment

Time Schedule	Pfizer Auditorium
Breakfast*	
08:00 – 08:25	Morning Plenary Talk: Prof. Zhong Lin Wang, Materials Science & Engineering, Georgia Tech
Morning Break**	

Time Schedule	Main Hall	Room 215	Room 474	Room 475
08:40 – 10:05	II(A) Nanoscale Technologies & Techniques	II(C) Sensor Platforms	III(A2) Nano-Electronics & Nano-Optics I	IV(B1) Control of Matter at the Nanoscale
Morning Break**				
10:25 – 12:10	II(A) Nanoscale Processes & Interactions	II(C) Architecture Design for Sensor Platforms	III(B2) Molecular-Level Probe	IV(A2) Novel Micro/Nano Structures for Sensing
Lunch Break**	★ Lunch Keynote Talk: Dr. James Klemic, MITRE Nanosystems Group, The MITRE Corporation			
13:30 – 13:55	★ Afternoon Plenary Talk: Prof. Nadrian Seeman, Department of Chemistry, New York University			
14:10 – 15:35	II(B) Nano-Enhanced Sensitivity	II(D) Nano-Enabled Imaging Technology	IV(B2) NanoFab for Sensing & Monitoring	IV(B1) Sensing at the Nanoscale
Afternoon Break**				
15:55 – 17:45	II(B) Nano-Enhanced Discrimination	IV(S2) Nanoscale Laser & Photonic Systems	III(A1) Micro-to-Nanoscale Characterization	III(C1) Functionalized O-I. Interfaces for Bio-Sensing
Dinner Break				

* Breakfast will be served in front of the Pfizer Auditorium

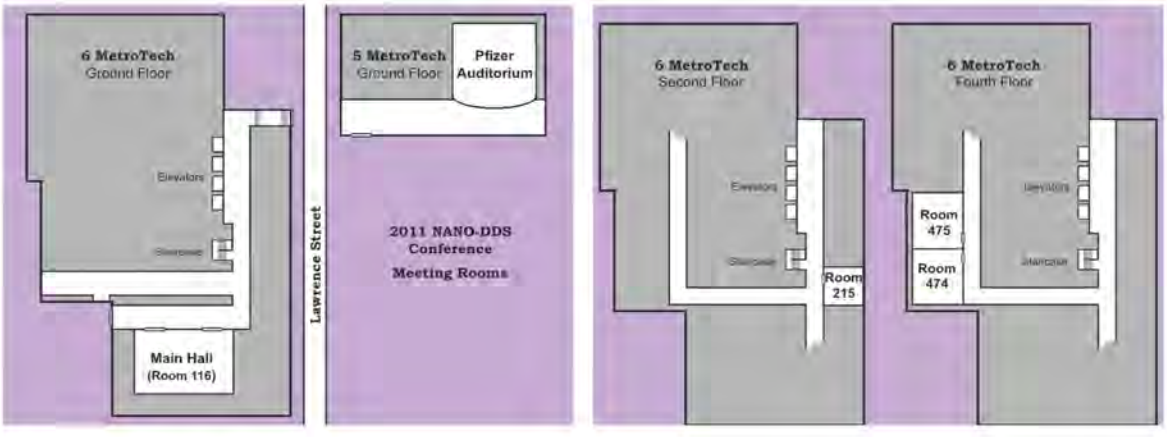
** Morning/Afternoon Break food & drinks will be served in front of the Main Hall

★ The Lunch Keynote & Afternoon Plenary Talks will be given in the Main Hall.
Lunches will be provided (to all conference attendees) in the Main Hall.

Time Schedule	Main Hall	
18:30 – 20:30	Poster Session ♦	

♦ Hors d'oeuvres will be served in the Main Hall during the poster session.

2011 NANO-DDS Conference Meeting Site Map



Notes

Tuesday Aug. 30: Keynote & Plenary Talks

Tuesday Aug 30	Location: Pfizer Auditorium
8:00-8:25	PIEZOTRONICS FOR SMART SYSTEMS
Plenary	Zhong Lin Wang, Georgia Institute of Technology 
12:15-12:45	Location: Main Hall
	NANOFORENSICS: NANOTECHNOLOGY FOR FORENSIC SCIENCE, VERIFICATION, AND VALIDATION APPLICATIONS
Lunch Keynote	James Klemic, The Mitre Corporation
13:30-13:55	STRUCTURAL DNA NANOTECHNOLOGY: FROM NANOMATERIALS TO NANOROBOTS TO NANODIAGNOSTICS
Plenary	Nadrian Seeman, New York University 

PEIZOTRONICS FOR SMART SYSTEMS
Zhong Lin Wang
Georgia Institute of Technology

Piezoelectricity, a phenomenon known for centuries, is an effect that is about the production of electrical potential in a substance as the pressure on it changes. The most well known material that has piezoelectric effect is the provskite structured Pb(Zr, Ti)O3 (PZT), which has found huge applications in electromechanical sensors, actuators and energy generators. But PZT is an electric insulator and it is less useful for building electronic devices. Wurtzite structures, such as ZnO, GaN, InN and ZnS, also have piezoelectric properties but they are not extensively used as much as PZT in piezoelectric sensors and actuators due to their small piezoelectric coefficients. In fact, due to the polarization of ions in a crystal that has non-central symmetry, a piezoelectric potential *(piezopotential)* is created in the crystal by applying a stress. For materials such as ZnO, GaN, InN in the wurtzite structure family, the effect of piezopotential to the transport behavior of charge carriers is significant due to their multiple functionalities of piezoelectricity, semiconductor and photon excitation. By utilizing the advantages offered by these properties, a few new fields have been created. Electronics fabricated by using innercrystal piezopotential as a "gate" voltage to tune/control the charge transport behavior is named *piezotronics,* with applications in strain/force/pressure triggered/controlled electronic devices, sensors and logic units. *Piezo-phototronic effect* is a result of three-way coupling among piezoelectricity, photonic excitation and semiconductor transport, which allows tuning and controlling of electro-optical processes by strain induced piezopotential. The objective of this talk is to introduce the fundamentals of piezotronics and piezo-phototronics and to give an updated progress about their applications in energy science and sensors.

NANOFORENSICS:
NANOTECHNOLOGY FOR FORENSIC SCIENCE, VERIFICATION, AND VALIDATION APPLICATIONS

James Klemic
The Mitre Corporation

Nanoforensics is a term developed by The MITRE Corporation to describe an emerging technology that combines advances from a number of different technical areas including nanotechnology, chemical functionalization, materials processing, metrology, and analysis for use in verification, validation, and characterization applications. Nanoforensics addresses the needs of the forensic science community as well as broader industry and Government needs for improvements in materials and methods for anti-counterfeiting, hardware security, quality assurance (QA), quality control (QC), and source verification applications. An overview of nanoforensics, factors driving its development, and potential applications will be presented. In addition, recent results will be presented from an ongoing MITRE Bio-Nanotechnology Laboratory effort focused on the development of nano-enabled taggants, biomorphic micro-tags with modular integrated nanoscale indicator structures. These taggants show promise for hardware cybersecurity applications, evidence chain-of-custody, and other QA/QC applications.

STRUCTURAL DNA NANOTECHNOLOGY: FROM NANOMATERIALS TO NANOROBOTS TO NANODIAGNOSTICS

Nadrian Seeman, Hari Subramanian, Banani Chakraborty, Hongzhou Gu, Tong Wang, Jianping Zheng,
Jens Birktoft, Ruojie Sha
New York University

Structural DNA nanotechnology uses branched DNA motifs to build novel materials, devices and systems on the nanometer scale. The idea behind it is that the chemical information in DNA can be used to direct these polymers to self-assemble into a variety of structures, some of which are capable of movement and other types of functions. Here, we describe the formation of crystalline matter, a nanoscale assembly line and a new diagnostic system. Structural DNA nanotechnology is based on stable branched DNA motifs. The sequence design of stable branched molecules uses minimized sequence symmetry. We have been working since the early 1980's to combine these DNA motifs to produce target species. We have constructed DNA stick-polyhedra and topological targets, such as Borromean rings. Branched junctions with up to 12 arms have been made. We have also built DNA nanotubes. A central goal of structural DNA nanotechnology is the self-assembly of crystalline matter. We have constructed 2-dimensional DNA arrays from many different motifs. Recently, we have self-assembled a 3D crystalline array and have solved its crystal structure to 4 Å resolution, using traditional unbiased crystallographic methods. Many other crystals have been designed following the same principles, including one with two molecules in the crystallographic repeat to control the color of the crystals. We have built a nanoscale assembly line by combining a DNA origami layer with three DNA devices, so that there are eight different states; we have programmed a novel DNA walking device to pass these three stations. As a consequence of proximity, the devices add a cargo molecule to the walker. We have demonstrated that all eight products can be built using this system. Recently, we have used DNA origami in a diagnostic tool. Single Nucleotide Polymorphisms (SNPs) are the most common genetic variations in the human genome. Here, we have combined the effectiveness of isothermal removal of strands with atomic force microscopy (AFM) of DNA origami patterns to produce a direct visual readout of the target nucleotide contained in the probe sequence. The origami contains graphical representations of the four possible nucleotide alphabetic characters, A, T, G and C. Each of the components of the letters contains a nucleotide at the test site that is the complement of one of the nucleotides in the probe. Consequently, the symbol containing the test nucleotide identity vanishes in the presence of the probe. Computer processing produces a direct symbolic readout that immediately identifies the nucleotide carried by the probe. This system works both for homozygous and heterozygous probes.

II. Sensor & Systems Applications

Tuesday Aug 30	Location: Pfizer Auditorium
8:00-8:25	PIEZOTRONICS FOR SMART SYSTEMS
Plenary	Zhong Lin Wang, Georgia Institute of Technology
	Location: Main Hall
Session II-A	NANOSCALE TECHNOLOGIES AND TECHNIQUES
	Chair: Bryan Horner, U.S. Defense Threat Reduction Agency (DTRA)
8:40-9:05	NEW POSSIBILITIES IN NANOTECHNOLOGY USING TABLE TOP EUV LASERS: NOVEL APPLICATIONS TO COHERENT IMAGING, PATTERNING AND MORE
Invited	Mario Marconi, Colorado State University
9:05-9:25	TOPOLOGICAL METHODS AND APPLICATION TO THE WIDE AREA DETECTION OF CHEMICAL AND BIOLOGICAL CONTAMINATION
	Daniel Kling, Folded Structures Company
9:25-9:45	DETECTION OF HUMAN AND AVIAN FLU VIRUSES USING GRAPHENE-COATED INFRARED SCREENS
	Amrita Banerjee, New Jersey Institute of Technology
9:45-10:05	USING MOLECULAR IMPRINTING TECHNIQUES FOR DETECTION OF CANCER MARKERS AND VIRAL PATHOGENS
	Miriam Rafailovich, Stony Brook University
10:05-10:25	MORNING BREAK (in front of Main Hall)

II-A. Nanoscale Technologies and Techniques

NEW POSSIBILITIES IN NANOTECHNOLOGY USING TABLE TOP EUV LASERS: NOVEL APPLICATIONS TO COHERENT IMAGING, PATTERNING AND MORE
Mario Marconi
Colorado State University

The recent demonstration of ultra-compact “table-top” laser systems that emit in the EUV, in the range of wavelengths between 10 and 50 nm open now the possibility to realize in small laboratory environments experiments that so far were restricted only to large synchrotron facilities. Using compact EUV lasers we have demonstrated several applications relevant to nano-science and nano-technology, like efficient nano-patterning by coherent photolithography, time-resolved interferometry of highly ionized dense plasmas, high resolution full field microscopy, nanomachining and high resolution holography. This talk will review the last achievements in the field with special emphasis in high resolution nano-imaging and coherent nano-patterning. High resolution holography with wavelength resolution was demonstrated using carbon nanotubes. This imaging technique allows recording of macroscopic objects (millimeters square) with wavelength (50 nm) resolution. The sample does not need any preparation and the imaging technique does not require any special optics or sophisticated alignment. Also it is possible, with an adequate image analysis to determine the depth information for a full characterization of the object in three dimensions. Novel schemes for nano-patterning of photoresists using coherent light will be presented that allow a large area replication of arbitrary motifs. This new nano-patterning approach has similar characteristics to the well developed nano-imprint technique, with the additional advantage that it is a non-contact, defect free optical technique. Prospects of new applications in time-resolved nano-imaging and high sensitivity detection systems based on nano-mechanical resonator arrays will be also discussed.

TOPOLOGICAL METHODS AND APPLICATION TO THE WIDE AREA DETECTION OF CHEMICAL AND BIOLOGICAL CONTAMINATION

Daniel Kling
Folded Structures Company-NJ

This reports on current work in topological data analysis to develop new topological methods for identifying chemical cloud formations in hyperspectral infrared data. The field case studied finds an acetic acid plume in 20 dimensional infrared data. Several topological approaches were investigated. Motivation is given to see the data set as a fuzzy CW-complex. A model for the CW-complex is developed. The CW-complex is used for defining a background estimator, with results comparable to using true background data. A similar method is given for modeling the idealized clutter-free data, and potentially this could be used for enhancing raw data in other applications. The approach is then repeated on a local neighborhood space as a means for clarifying the texture of images. This is applied to gray scale and three channel photographs. In this experiment the local pixel patterns collectively are seen to be represented by a fuzzy CW-complex, and so by naming the ideal complex and by mapping onto the complex the clutter is removed from the image.

DETECTION OF HUMAN AND AVIAN FLU VIRUSES USING GRAPHENE-COATED INFRARED SCREENS

Amrita Banerjee, Sumit Chakraborty, Haim Grebel
New Jersey Institute of Technology, Weill Cornell Medical College-NYC

We have devised a novel infrared method to distinguish between avian and swine flu and investigated the binding between the influenza viruses and their respective receptors. Metallo-dielectric screens (IR screens) have been investigated from the visible to the THz spectral region for astronomy and remote sensing applications. These screens are made of periodic structure aim to invoke surface plasmon polariton (SPP) modes. These surface modes enable a better coupling between the incident beam and the molecules under test. Yet, in order to achieve such goal, one needs to devise a bio-compatible platform that enhances the respective infrared (IR) signals. Graphene is a monolayer thick crystal of carbon. Graphene is chemically inert, thermodynamically stable and mechanically strong. Recently, we were able to fabricate mono and a few-layers graphene on solid and perforated substrates. IR spectroscopy is a useful spectroscopic tool to assess bio-molecular vibrations and provides with molecular fingerprinting. By combining the properties of graphene-coated IR screens with a model membrane imbedded with receptors, we were able to devise a bio-compatible platform for the detection of bio-molecules.

USING MOLECULAR IMPRINTING TECHNIQUES FOR DETECTION OF CANCER MARKERS AND VIRAL PATHOGENS

Miriam Rafailovich, Yantian Wang
Stony Brook University-NY

Rapid identification of pathogens can be an essential element in containment and spread of contagious diseases. Similarly, identification of cancer markers or other proteins at beside can be influential in making quick decisions regarding biopsies or treatment. Molecular imprinting using artificial materials provides an alternative to the detection of a large variety of substances, ranging from viral proteins, intact viruses, and bacteria. We show that surface molecular imprinting can be accomplished on elements, with three dimensional topographies, coated with self-assembled monolayers to design sensing elements for the detection of cancer biomarkers and other proteins. These elements consist of a goldcoated silicon chips onto which hydroxyl-terminated alkanethiol molecules and template biomolecule are co-adsorbed, where the thiol molecules are chemically bound to the metal substrate and self-assembled into highly ordered monolayers. When the biomolecules are removed, they create a foot print specific for the molecule. Re-adsorption of the biomolecules to the sensing chip changes its potential, which can be measured potentiometrically. We applied this method to the detection of carcinoembryonic antigen (CEA) in both solutions of purified CEA and in the culture medium of a CEA-producing human colon cancer cell line.

II. Sensor & Systems Applications

Tuesday Aug 30	Location: Pfizer Auditorium
8:00-8:25	PIEZOTRONICS FOR SMART SYSTEMS
Plenary	Zhong Lin Wang, Georgia Institute of Technology
	Location: Room 215
Session II-C	SENSOR PLATFORMS
	Chair: Clint Smith, U.S. Army ERDC
8:40-9:05	DEPLOYABLE, NANOSCALE SENSOR PLATFORM FOR DETECTION OF BIOLOGICAL AND CHEMICAL AGENTS
Invited	Melanie Tomczak, UES, Inc.
9:05-9:25	FLUORESCENTLY LABELED CELLULAR SURROGATES FOR LOSS OF SIGNAL DETECTION FOR AUTOMATED MICROORGANISM DETECTION IN LIQUIDS
	Michael Anderson, Michigan State University
9:25-9:45	CARBOHYDRTE FUNCTIONALIZED SCREEN PRINTED CARBON ELECTRODES FOR FIELD BASED MULTIPLEX BACTERIAL DETECTION
	Barbara Cloutier, U.S. Army Research Laboratory
9:45-10:05	NANO-APERTURE FIBER HYDROGEN SENSORS
	Lynford Goddard, University of Illinois at Urbana-Champaign
10:05-10:25	MORNING BREAK (front of Main Hall)

II-C. Sensor Platforms

DEPLOYABLE, NANOSCALE SENSOR PLATFORM FOR DETECTION OF BIOLOGICAL AND CHEMICAL AGENTS
Melanie Tomczak
UES,Inc.

UES is developing sensor systems that can be deployed and deliver results in real-time as the agents of interest interact with the sensor platform. The sensor systems have been developed to report these detection events remotely via wireless communication paths. These systems could yield tremendous information about what biological or chemical agents may be found a deployed area and render a map of hotspots in a designated area. The platform to be discussed here is based on metal nanoisland architecture that results in multiplicative amplification of a positive binding event. The sensor platform itself can be multiplexed and can utilize different classes of ligands, including peptides, aptamers, glycans or antibodies, within the same framework. This has the potential to lead to the forensic identification of biological or chemical agents in a field setting. For example, different sensing cartridges could be functionalized with ligands to specifically identify a set of biological or chemical agents and/or to distinguish between different species of the same bacteria, for example the *Bacillus* spp.; different types of biological agents, for example virus, bacteria, fungus, vegetative cells or spores; or different classes of chemical agents. Eventually, all of these ligands could be integrated into the same catridge or into a series of cartridges that could be inserted into the same sensing platform. These results are then wirelessly transmitted to a command and control unit (either local or remote) that then processes the information and reports a result. This sensor platform, which can be used with both air and water samples, would be a benefit to the Warfighter, the Department of Homeland Security, as well as to First Responder and Civilian applications.

FLUORESCENTLY LABELED CELLULAR SURROGATES FOR LOSS OF SIGNAL DETECTION FOR AUTOMATED MICROORGANISM DETECTION IN LIQUIDS

Michael Anderson, Shannon McGraw, Evangelyn Alocilja
Michigan State University

The aim of this paper is to use fluorescence of a DNA binding stain to create a loss of signal sensor for remote sensing applications. Target pathogens include potentially any whole single cell organism with an available antibody. Antibody based sensing allows for highly specific detection of protein targets, whole cell surface antigens or toxins. Antibodies conjugated to fluorescent molecules have been used to report the location of the antibody after binding to the target antigen. The use of an antibody sandwich, such as in an ELISA test, provides both a target capture element and two forms of recognition for the target as each antibody is required to bind for detection. The requirement of an applied second antibody has limited the use of ELISA style assays for real time or remote sensing applications. Automated and remote sensing can be accomplished through a competition style assay utilizing only a single antibody and a fluorescently labeled surrogate target antigen. The previously labeled secondary antibody reporter is replaces with an inactivated target microorganism that has similar antigenic elements as the environmental target. This surrogate is labeled with a highly fluorescent stain and the stained surrogate is stable for more than three months. The antibody is covalently bound to a glass surface, and stained surrogate is loaded on to the antibody. This initial loading emits a base level of signal, when an environmental target displaces the surrogate a loss of this signal is observed. This sensing element removes the need for a secondary antibody reagent dispensing system, has a reduced complexity and cost than an ELISA, and can be operated remotely for remote sensing applications.

CARBOHYDRTE FUNCTIONALIZED SCREEN PRINTED CARBON ELECTRODES FOR FIELD BASED MULTIPLEX BACTERIAL DETECTION

Barbara Cloutier, Michael Anderson
U.S. Army Research Laboratory

Food based testing systems for microorganisms have a paucity of accurate, real time detection techniques that can effectively detect in the complex matrices that make up this category. Matrix interference and non homogeneous distribution effect sensitivity, necessitating overnight enrichment for the existing techniques. There are even less field ready techniques. To address this concern a carbohydrate coated screen printed carbon electrode (FSPCE) was developed and validated to detect *Escherichia coli* O157:H7 in broth and milk. This shelf stable, universal electrode has been evaluated against 57 organisms in 10 different genuses and has effectively captured them all. With any differential capture method, these functionalized electrodes can be used to immobilize and detect multiple organisms using cellular impedance on a hand held potentiostat, in the field. Statistically significant detection in broth ($p=0.04$; $n=20$) of *Escherichia coli* O157:H7 down to 1-2 cells was accomplished within one hour. Preliminary whole milk trials demonstrated a 100% correlation with the gold standard Food and Drug Administration method. Longevity studies out to 2 months showed no significant difference in performance with room temperature storage. The universality of capture for multiple types of bacteria in multiple matrices of these functionalized electrodes and their shelf stable format allow detection in the harsh environments of the field, a significant improvement over the laboratory intensive methods used in detection currently.

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NANO-APERTURE FIBER HYDROGEN SENSORS

Steve McKeown, Lynford Goddard
University of Illinois at Urbana-Champaign

There is strong research interest in developing lightweight gas sensors capable of ppm sensitivity and extended operation at low power. Photonics-based sensors can potentially meet these objectives and offer a low sparking hazard and the ability to miniaturize, integrate, and array. Here, we present our prototype fiber based hydrogen sensor that uses palladium (Pd) as a reversible chemical to optical transducer. A nano-aperture is etched onto the facet of a Pd coated fiber tip and the concentration of hydrogen is determined through polarization dependent loss measurements of light that is reflected and transmitted through the nano-aperture. Nano-apertures can be made extremely sensitive to the material properties due to their effects on resonant transmission.

III. Device Concepts & Sensor/System Functionality

Tuesday Aug 30	Location: Pfizer Auditorium
8:00-8:25	PIEZOTRONICS FOR SMART SYSTEMS
Plenary	Zhong Lin Wang, Georgia Institute of Technology
	Location: Room 474
Session III-A2	NANO-ELECTRONICS & NANO-OPTICS I
	Chair: William Clark, U.S. Army Research Office (ARO)
8:40-9:05	ULTRA-LOW POWER INTERCONNECTS FOR NANOELECTRONICS
Invited	Azad Naeemi, Georgia Institute of Technology
9:05-9:25	BRANCHED INDIUM ANTIMONIDE NANOWIRE ARRAYS AS ANTI-REFLECTIVE STRUCTURES FOR INFRARED DEVICES
	David Janes, Purdue University
9:25-9:45	BROADLY TUNABLE INFRARED LASERS FOR MOLECULAR SPECTROSCOPY
	Steven Brueck, University of New Mexico
9:45-10:05	AN INTERBAND InAs/GaSb MICRO-PILLR ARRAY FOR LONG WAVELENGTH SOURCE
	Weidong Zhang, North Carolina State University
10:05-10:25	MORNING BREAK (in front of Main Hall)

III-A2. Nano-Electronics & Nano-Optics I

ULTRA-LOW POWER INTERCONNECTS FOR NANOELECTRONICS
Azad Naeemi
Georgia Institute of Technology

Interconnects account for more than half of the power dissipation in integrated circuits and they continue to be a growing challenge for nanoelectronics. The first part of this talk will talk about ultra-low power carbon nanotube and graphene nanoribbon interconnects for field effect devices in computing and sensing applications. In the second part of the talk, interconnect aspects of emerging non-voltaic switches such as spintronic devices will be discussed. It will be shown that interconnects for emerging non-voltaic devices are inherently slow but may potentially offer lower power dissipation compared to their electrical counterparts..

BRANCHED INDIUM ANTIMONIDE NANOWIRE ARRAYS AS ANTI-REFLECTIVE STRUCTURES FOR INFRARED DEVICES
David Janes, Asaduzzaman Mohammad, Suprem Das, Mohammad Khan, Muhammad Alam
Purdue University

Nanostructured assemblies can provide unique electronic and optical properties. In this presentation, we describe the development and characterization of two-dimensional arrays of branched Indium Antimonide (InSb) nanowires. In contrast to a ~ 40% optical reflection expected for an air-tobulk InSb interface, the measured reflectance from the array of InSb nanowires is less than 5% over the near infrared (IR) range. The structure provides a tapered dielectric transition from air to the body of the nanowires. An integrated modeling effort provides insights into the dielectric transition as well as the regions in which the IR is absorbed. The narrow bandgap of InSb makes it well suited for detector/imager applications in the IR. The development of a low-reflection transition based on nanostructuring of the surface, coupled with the ability to control the optical and electronic properties of the material by control of nanowire dimensions, can enable new approaches for detecting and integrating IR signals and images.

BROADLY TUNABLE INFRARED LASERS FOR MOLECULAR SPECTROSCOPY

Xiang He, Steven Benoit, Ron Kaspi, Steven Brueck
University of New Mexico, U.S. Air Force Research Laboratory-Kirtland AFB, NM

A new approach to tunable infrared lasers, an optically pumped, type-II GaSb:InAs gain medium with a chirped distributed feedback grating is reported. Quasicontinuous tuning of over 65 nm in the important C-H stretch region at 3.3 mm is reported with over 1 W of narrow band output suitable for atmospheric pressure spectroscopy of small molecules is reported. Dependence of the lasing performance on the parameters of the chirp is discussed both experimentally and theoretically. Molecular spectroscopy of CH4 is demonstrated.

AN INTERBAND InAs/GaSb MICRO-PILLR ARRAY FOR LONGWAVELENGTH SOURCE

Weidong Zhang, Dwight Woolard
North Carolina State University, U.S. Army Research Office

This presentation will analyze a new far-infrared laser concept based upon InAs/GaSb broken-gap materials, structures and micro-pillar arrays that demonstrate the potential for generating high optical gain/power and tunability at room temperature. Such a compact, solid-state source is of importance for use in numerous field sensing applications including the detection chemical/biological agents, environmental/atmospheric monitoring, and for medical diagnostics. This far-infrared laser design will leverage regular arrays of InAs/GaSb superlattice pillars that may be defined by MBE growth of two-dimensional (2-D) stacked heterostructures that are reduced to individual diameters as small as 20 nm by conventional nanolithography. Here, each micro-pillar defines a single double-barrier diode with band alignments. The GaSb layers present potential barriers for electrons and wells for holes, which leads to the upper confined state E_2 in the conduction band (CB) and the lower heavy-hole (HH) confined state E_1 in the valence band (VB). Hence, when an external bias is applied the electrons that are resonantly injected into E_2 will have the opportunity to recombine with HHs trapped at E_1 if sufficient interband tunneling (i.e., from E_1 to collector region) exists to generate a population inversion.

IV. Materials, Fabrication and Integration for Sensor/System Architectures

Tuesday Aug 30	Location: Pfizer Auditorium
8:00-8:30	PIEZOTRONICS FOR SMART SYSTEMS
Plenary	Zhong Lin Wang, Georgia Institute of Technology
	Location: Room 475
Session IV-B1	CONTROL OF MATTER AT THE NANOSCALE
	Chair: Michael Norton, Marshall University
8:40-9:05	SYNTHETIC BIOLOGY AND LEGACY FORENSICS
Invited	Steven Benner, Firebird Biomolecular Sciences, LLC
9:05-9:25	DESIGNED METAL NANOSTRUCTURES AND ASSEMBLIES FORMED FROM SCAFFOLDED DNA ORIGAMI
	Adam Woolley, Brigham Young University
9:25-9:45	ADDRESSING PROTEINS ONTO SINGLE AND 2D DNA ORIGAMI NANOCONSTRUCTS
	Masudur Rahman, Marshall University
9:45-10:05	SURFACE-DIRECTED VAPOR-LIQUID-SOLID (SVLS) GROWTH PROCESS: OPPORTUNITIES AND CHALLENGES IN SCALABLE NANOWIRE ASSEMBLIES
	Babak Nikoobakht, Surface and Microanalysis Science Division-NIST
10:05-10:25	MORNING BREAK (in front of Main Hall)

IV-B1. Control Of Matter at the Nanoscale

SYNTHETIC BIOLOGY AND LEGACY FORENSICS
Steven Benner, Shuichi Hoshika, Zunyi Yang
Firebird Biomolecular Sciences, LLC-FL, Foundation for Applied Molecular Evolution-FL

Advances in our understanding of nucleic acids have made DNA-targeted analyses the touchstone of criminal and military forensics. Further, polymerase chain reaction (PCR) allows, in principle, the analysis of single molecules of DNA, offering the hope that forensic calls might be made from samples that have suffered extensive degradation. The only factors preventing DNA-targeted analysis from universal application are the unfortunate chemical behaviors intrinsic to DNA, and the unfortunate defects intrinsic to PCR when applied to complex biological samples. DNA is unstable, both to chemical and enzymatic degradation. Reagents to preserve legacy specimens often damage DNA. Even when single molecules of DNA remain in a sample, PCR amplification is troubled by off-target binding of primers, background and artifacts. These together place limits on the signal that can be detected above the noise in real, complex, biological samples. Since these problems in legacy forensics arise from reactivities intrinsic to DNA itself, it is unlikely that they will be solved bynanoscale devices. Rather, reagents are needed to manage these intrinsic reactivities. The Benner group has developed a nested PCR approach to forensic analysis of legacy samples to manage the intrinsic reactivities of DNA and to enhance signal:noise in complex biological samples. Enhancement comes from incorporation of components from an artificially expanded genetic information system (AEGIS) into the external primers for this purpose. While basic research, this combination is supporting the development of FBI CODIS-targeted forensic tools, which will be discussed.

DESIGNED METAL NANOSTRUCTURES AND ASSEMBLIES FORMED FROM SCAFFOLDED DNA ORIGAMI

Adam T. Woolley, Yanli Geng, Elisabeth Pound, Jianfei Liu, Matthew Halbert, Shailendra Gyawali, Bibek Uprety, Anthony C. Pearson, Robert C. Davis, John N. Harb
Brigham Young University

Our research involves the construction of designed nanostructures with narrow linewidths and overall footprints in the few hundreds of nanometers. We use the method of scaffolded DNA origami to create thin and branching nanostructures with a diversity of architectures. These DNA origami templates can then be decorated selectively with metal using a variety of approaches. We have demonstrated both silver and palladium seeding methods on DNA origami, which enable subsequent electroless plating with metals such as gold and palladium to yield designed metal nanostructures with linewidths as thin as 30 nm. Additionally, we have developed a gold nanoparticle seeding method that allows site-selective metallization within DNA origami and the formation of engineered gaps. We are presently exploring the electrical and optical properties of these metallized nanostructures. We anticipate applications of our hybrid DNA-metal systems in bottom-up nanofabrication, photonics, sensing and electronics.

ADDRESSING PROTEINS ONTO SINGLE AND 2D DNA ORIGAMI NANOCONSTRUCTS

Masudur Rahman, Hong Zhong, David Neff, Michael L. Norton
Marshall University, Parabon NanoLabs

We report a stepwise study to address NeutrAvidin (NA) protein to specific locations on single DNA-origami-based nanostructures and a 2D array of Cross shaped origami. The NA proteins were addressed to biotin functionalized sites on a rectangular origami construct. To produce larger addressable areas we've prepared 2D arrays of the cross shaped origami measuring ~1.5x1μm2 in size. Organizing functional proteins or enzymes in a well-designed pattern has great significance in biosensing and other applications; however an important goal of nanotechnology is to assemble multiple molecules while controlling the spacing between them. Self-assembled DNA Nanoconstructs such as DNA origami provide the most effective pathway for producing large area platforms, which are addressable at high resolution. In this stepwise study, two types of DNA origami nanostructures (Rectangular and Cross shaped) were designed with addresses for the NA protein. We have selected to immobilize NA on origami nanostructures to use as probes for biotinylated antibodies, GFP and other molecular species.

SURFACE-DIRECTED VAPOR-LIQUID-SOLID (SVLS) GROWTH PROCESS: OPPORTUNITIES AND CHALLENGES IN SCALABLE NANOWIRE ASSEMBLIES

Babak Nikoobakht
Surface and Microanalysis Science Division-NIST

A surface-directed vapor-liquid-solid (SVLS) growth method is discussed in which horizontal nanowires grow from individual Au nanodroplets, and their alignment is dictated by the underlying substrate. The SVLS process maintains the strength of the traditional VLS-based methods in growth of nanowires, while enabling a unique control over their hierarchical assemblies. We discuss the concept of "smart surfaces" for planar growth of some semiconductor oxides such as ZnO and TiO2. In this presentation we show the impact of the substrate on growth direction of nanowires and formation of bi- and tri-directional assemblies as well as n-p heterojunctions. We show some of our recent results on use of different single crystal surfaces as substrates to elucidate factors contributing to the directionality of the nanocrystals growth. High resolution electron microscopy analysis of the formed n-p heterojunctions shows a nearly coherent interface without defects such as threading dislocations known in the III-V nitride family. We also present different schemes for charge injection to heterojunctions arrays and discuss their electro-optical properties, weaknesses and strengths.

II. Sensor & Systems Applications

Tuesday Aug 30	Location: Main Hall
Session II-A	NANOSCALE PROCESSES & INTERACTIONS
	Chair: Janet Jensen, U.S. Army Edgewood Chemical & Biological Center (ECBC)
10:25-10:50	BIOTECHNOLOGY ICS: MICROARRAYS, DNA SEQUENCERS, AND BEYOND
Invited	Arjang Hassibi, University of Texas-Austin
10:50-11:10	NANOSCALE PHOTOVOLTAICS, ALGAL BIOSENSORS AND THE PROTECTION OF SOURCE DRINKING WATERS AGAINST CHEMICAL ATTACKS
	Elias Greenbaum, Oak Ridge National Laboratory
11:10-11:30	PICOMOL DETECTION OF TRICHOTECIN MYCOTOXINS BASED ON DIPAIN INDUCED FLUORESCENCE
	Nicolai Panikov, L.C. Pegasus Corp
11:30-11:50	SEMICONDUCTOR LAYERED NANOMATERIALS TO ENCAPSULATE AND TRAP HAZARDOUS ORGANIC COMPOUND
	Amin El-Meligi, National Research Centre-Cairo, Egypt
11:50-12:10	ELECTRICALLY–ACTIVE MAGNETIC NANOPARTICLES AS CONCENTRATOR AND REPORTER IN ANTHRAX DETECTION
	Evangelyn Alocilja, Michigan State University
12:15-13:30	LUNCH BREAK: Main Hall
Lunch Keynote	NANOFORENSICS: NANOTECHNOLOGY FOR FORENSIC SCIENCE, VERIFICATION, AND VALIDATION APPLICATIONS
	James Klemic, The Mitre Corporation

II-A. Nanoscale Processes & Interactions

BIOTECHNOLOGY ICs: MICROARRAYS, DNA SEQUENCERS, AND BEYOND
Arjang Hassibi
University of Texas-Austin

The recent advances in biotechnology are largely due to the progress in bio-molecular detection and analysis platforms, especially in microarray, DNA sequencing, and qPCR technologies. However, current performances of these platforms (SNR, dynamic range, response time, throughput, and etc.) as well as their complexity and bulkiness are far from the ideal. It is fair to say that we still have a long way to go to realize high performance, hand-held, and integrated systems for applications such as personal medicine, point-of-care molecular diagnostics, and real-time environmental monitoring. Recently, a new technology trend has emerged in biotechnology, which promises not only detection sensitivity, but also integration and manufacturability. The general idea is to leverage the capabilities of conventional silicon VLSI fabrication technologies, e.g., CMOS processes, and build ICs that can act as the backbone for bio-molecular analysis platforms. Recent examples are CMOS integrated microarrays and high-throughput DNA sequence-by-synthesis systems. The focus of this talk is to introduce this particular technology trend and discuss its advantages and limitations. Initially, we will discuss the performance metrics of bio-molecular analyzers such as specificity, detection dynamic range (DDR), and minimum detection level (MDL) and furthermore explain the various signal modalities that their detectors use. Next, we will introduce the CMOS integrated biosensor platform and describe the methods by which conventional ICs can be enhanced to carry out bio-molecular detection in affinity-based microarray and DNA sequencing assays. In the rest of this talk, we will provide specific examples on different ICs that we have developed recently for these applications, which also accommodate electro-analytical, bioluminescence, and fluorescence signal modalities.

NANOSCALE PHOTOVOLTAICS, ALGAL BIOSENSORS AND THE PROTECTION OF SOURCE DRINKING WATERS AGAINST CHEMICAL ATTACKS

Elias Greenbaum, Michael Rodriguez, Jr.
Oak Ridge National Laboratory

The purpose of this presentation is a description of algal biosensor technology for the detection and characterization of toxins that are representative of chemical agents of interest in homeland security and the protection of source drinking waters and marine environments. The agents are cyanide, methyl parathion, Diuron®, atrazine and paraquat. The novel aspect of the technology is the use of indigenous microalgae and cyanobacteria that grow in all surface source drinking waters. The conversion of visible light energy into chemical energy by photosynthesis begins with photon absorption and vectorial charge separation in the nanoscale photovoltaic reaction centers that are embedded in photosynthetic membranes. Variable fluorescence from the Photosystem II reaction center of algae that grow in all surface source drinking waters can be used to detect the introduction of chemical agents and environmental pollutants. This presentation will consist of two parts. First, a review of results for the detection limits for real-time source water monitoring using indigenous freshwater microalgae will be presented. The detection limits were calculated from the photochemical efficiency of the Photosystem II reaction center using well-known principles of variable fluorescence induction. Second, we show that differential offset analysis of the complete time-dependent fluorescence curve can be used to extract a digital "fingerprint." The digital signal was obtained using differential offset analysis of the fluorescence induction curves. In principle, this technique allows both detection and the chemical grouping of selected classes of toxins. Based on the molecular architecture of the photosynthetic membrane, we explain why a degree of specificity for different classes of chemical toxins is to be expected. The motivation for this work was to find a practical solution to the monitoring and protection of source drinking waters that have the following characteristics: (i) the ability to extract information from minute changes in a natural aqueous environment; (ii) no sample preparation; (iii) tolerant of sediment and debris; (iv) sentinel + chemical identification; (v) stand off and hands off detection; (vi) no consumable reagents; (vii) electromagnetically silent until an event has occurred; (viii) mobile; (ix) direct line of sight is not required; (x) wireless encrypted bidirectional telecommunication; (xi) Broad spectrum of aqueous toxins.

PICOMOL DETECTION OF TRICHOTECIN MYCOTOXINS BASED ON DIPAIN INDUCED FLUORESCENCE

Nicolai Panikov, Michael Norton, Thomas Koscica, Boris Gelmont, Brittany Caudill, Melanie Butt, Dawn Nicholas, Anshuman Mangalum, Janet Jensen, James Jensen, Hong-Liang Cui
L.C. Pegasus Corp., Marshall University, Northeastern University, University of Virginia,
NYU-Poly, U.S. Army ECBC

Robust and inexpensive fluorescence technique for detection of mycotoxin T-2 has been suggested. As compared with original method (Novak & Quinn-Doggett, 1991), our modification is more sensitive (detection limit as low as 1 picomole of T-2 surrogate) and the assay can be done in solution rather than after time- and energy consuming drying of sample.

SEMICONDUCTOR LAYERED NANOMATERIALS TO ENCAPSULATE AND TRAP HAZARDOUS ORGANIC COMPOUNDS

A.A. El-Meligi
National Research Centre-Cairo, Egypt

Semiconductor nanomaterials (FePS3 and MnPS3) were intercalated with organic compounds, N,N'-dimethyl-4,4'-bipyridinium (DBP) and pyridinium cations. The resultant compounds have been characterised by X-ray diffraction (XRD). Insertion of the DBP expands lattice spacing by 3.4Å with respect to FePS3 and MnPS3. There was no phase transformation of leaving the intercalated sample in open atmosphere. Insertion of pyridinium expands lattice spacing by 3.4Å and 5.9Å with respect to FePS3 and MnPS3. Phase transformation occurred after leaving the sample in open atmosphere for few days. The molecular size of intercalates may play a role in the lattice expansions. The XRD patterns exhibit sharp <00l> reflections of the intercalated compounds. This means that materials are of crystalline nature. The intercalation of such materials enables the encapsulation of hazardous organic compounds, such as DBP, which may be applied safely.

ELECTRICALLY–ACTIVE MAGNETIC NANOPARTICLES AS CONCENTRATOR AND REPORTER IN ANTHRAX DETECTION

Evangelyn Alocilja, Sudeshna Pal
Michigan State University

Nanoparticle (NP) based biosensors are emerging as rapid, sensitive and cost effective devices in biodefense and diagnostics. Magnetic polymer nanostructures are a new class of multifunctional nanomaterials that have been explored in such devices. In this paper, we report the novel application of electrically-active magnetic (EAM) nanoparticles as concentrator of B. anthracis, the causative agent of anthrax. Antibodies (Ab) specific to *B. anthracis* are functionalized on the EAM nanoparticle surface and these Ab-EAM NPs are used to extract the target organism from the matrix using a magnetic field. Then the isolated organism is lysed and DNA targeting the *pagA* gene of *B. anthracis* is amplified. DNA probes specific to the *pagA* gene are functionalized on another set of the EAM NPs and these are used to extract the target DNA from the DNA matrix. The electrical properties of the magnetic nanoparticles are used to report by electrochemical means.

II. Sensor & Systems Applications

Tuesday Aug 30	Location: Room 215
Session II-C	ARCHITECTURE DESIGN FOR SENSOR PLATFORMS
	Chair: Jeremy Robinson, U.S. Naval Research Laboratory (NRL)
10:25-10:50	ARMY ENVIRONMENTAL SENSING: FROM BENCH TO FIELD
Invited	Don Cropek, U.S. Army Corps of Engineers
10:50-11:10	ORTHOPTERNET RF COMMUNICATIONS
	David Rhodes, OpCoast LLC
11:10-11:30	DESIGNS AND TETS OF THE NANOWIRE BASED ELECTRONIC NOSES: FROM NANOWIRE NETWORK TO A SINGLE NANOBELT AS SENSING ELEMENTS
	Andrei Kolmakov, Southern Illinois University-Carbondale
11:30-11:50	IMAGING AT THE NANOSCALE WITH BROAD AREA EXTREME ULTRAVIOLET MICROSCOPES
	C.S. Menoni, Colorado State University
11:50-12:15	MULTI-STATES ELECTROMECHANICAL SWITCH FOR PARALLEL DATA PROCESSING AND NANOTUBE FET FOR BALLISTIC TRANSPORTATION
Invited	Muhammad Hussain, King Abdullah University of Science and Technology –Saudi Arabia
12:15-13:30	LUNCH BREAK: Main Hall
	NANOFORENSICS: NANOTECHNOLOGY FOR FORENSIC SCIENCE, VERIFICATION, AND VALIDATION APPLICATIONS
Lunch Keynote	James Klemic, The Mitre Corporation

II-C. Architecture Design for Sensor Platforms

ARMY ENVIRONMENTAL SENSING: FROM BENCH TO FIELD
Don Cropek
U.S. Army Corps of Engineers-IL

One relatively new U.S. Army Corps of Engineer mission is protection and maintenance of military lands and installations for sustainable use. In this regard, USACE has invested resources in research to develop robust, standalone, sensitive sensors for rapid environmental assessment at friendly sites as well as for quick screening applications at forward base locations under far more challenging conditions. In this talk, I will provide a top down discussion of our work in this arena from platform product development that utilizes chip components and chemistries designed for particular applications, arising from knowledge derived from our basic research. I will begin with an introduction to our SafePort program where our overarching goal is to construct integrated devices that can take a water sample, introduce it onto a modular lab on a chip, and obtain an actionable answer in the field targeted at a particular contaminant of Army interest. Chemistry embedded on a chip for quantification of the heavy metal lead, the number one ranked Army emerging contaminant perchlorate, and a nonspecific multianalyte water toxicity sensor will be described. Biosensing using cell based constructs is a major direction of our laboratory through our Water Toxicity program and aspects of microfluidic design, fluid flow, channel interconnects, cell culture, and miniaturized detection schemes that have grown from this program will be covered. Finally, current advances in creating synthetic cells that have the potential to replace living cells in our biosensors will be discussed.

ORTHOPTERNET RF COMMUNICATIONS

Benjamin Epstein, Serkan Sayilir, Byunghoo Jung, Harry Diamond, David Rhodes, Hong Liang
Purdue University, OpCoast LLC-NJ, Texas A&M University

OrthopterNets are ad hoc communications networks formed by insects to pass information from sensors to one or more detection endpoints. The networks may be formed by the natural calling of insects to one another (e.g., as with crickets and katydids) or through RF transceivers attached to the insects. This paper summarizes ongoing work with the RF transceivers. “OrthopterNets” represents an ongoing R&D program which aims to apply insects as relays for chemical detection and other sensor messages over distances of a few meters to hundreds or thousands of meters. This concept is named after the insect order Orthoptera, which includes common crickets, katydids, and related calling insects. One form of OrthopterNets currently under development makes use of calling insects whose calls are modulated via electro-mechanical means to carry a simple message. In the other network form, non-calling insects carry RF relay transceivers. This paper focuses on the latter approach. Applications of OrthopterNets include chem-bio sensor message transmission for the warfighter, as well as sensor communications for search and rescue assistance. In either case, swarms of specially equipped insects are released in the area of interest to aid in sensor message transmissions.

DESIGNS AND TETS OF THE NANOWIRE BASED ELECTRONIC NOSES:
FROM NANOWIRE NETWORK TO A SINGLE NANOBELT AS SENSING ELEMENTS

Andrei Kolmakov
Southern Illinois University-Carbondale

The progress in the development of the nanowire based electronic micro analytical systems for chemical sensing is described. The design evolution of the sensing elements from random nanowire network to ultimately small single nanowire is described. The performance and perspectives of such devices is analyzed. The development of simple, inexpensive, power efficient, robust and yet sensitive nanodevices for real-time analysis of the ambient gas is currently an imperative for homeland security. One of the approaches to develop a novel sensing platform was based on mimicking the mammalian olfactory system, which nowadays is often referred to as “electronic nose” (E-nose). The recent nanotechnology advancements allow the fabrication of E-noses in the size domain where miniaturization of the “classical” thin film micro analytical systems encounters principal limitations. Here we describe the evolution of the nanowire based electronic noses.

IMAGING AT THE NANOSCALE WITH BROAD AREA EXTREME ULTRAVIOLET MICROSCOPES

C.S. Menoni, S. Carbajo, I. Howlett, M.C. Marconi, J.J. Rocca
Colorado State University

Advances in nanotechnology drive the development of powerful practical imaging systems that could resolve nanoscale objects and track their dynamics. We describe the successful implementation of full-field microscope test beds based on compact extreme ultraviolet (EUV) lasers that have achieved a spatial resolution better than 38 nm. The full field microscopes are the analogs of optical microscopes that owe their 10X higher resolving power to the use of extreme ultraviolet laser illumination with wavelengths ranging from 13 to 47 nm. The microscopes also exploit the short pulse duration and high photon energy of the illumination in the flash imaging of nano-mechanical systems and make movies of their nanoscale dynamics. The EUV microscopes can be implemented in reflection and transmission geometry. In reflection the microscope have rendered images of surfaces, such as that of semiconductor chips in different stages of processing. In transmission configuration, the microscopes have imaged nanostructures, such as carbon nanotubes with a single laser shot of 1.5 ns duration. With this arrangement, we have been able to fully characterize the perturbed oscillation of a micro-electro-mechanical system (MEMS) device in the presence of a magnetic field. Snapshots of a magnetic force microscopy (MFM) tip oscillating at 82 kHz were acquired while lift-mode scanning a surface with a ferromagnetic dot array pattern. This technique not only provides precise measurements of the amplitude shifts caused by the interaction of the tip with the vertical component of a magnetic force gradient from the surface, but it also comprises a valuable method to assess the dynamics of nanostructures through direct visual animations.

MULTI-STATES ELECTROMECHANICAL SWITCH FOR PARALLEL DATA PROCESSING AND NANOTUBE FET FOR BALLISTIC TRANSPORTATION

Muhammad Hussain, Hussam Kloub, Hossain Fahad
King Abdullah University of Science and Technology –Saudi Arabia

Energy efficient and high performance computations are two integral components of today’s defense technology. Due to continuous device scaling we are achieving much higher performance but with associated leakage current originated excessive power consumption. Thus it is important to study alternative nanoelectronics such as nano-electro-mechanical switch (NEMS) and nano-structured (nanotube or nanowire) FETs. Therefore, we present a design and simulation results of electromechanical switches enabling parallel data processing and multi functionality (Fig. 1). The device is applied in logic gates AND, NOR, XNOR, and Flip-Flops. The device footprint size is 2µm by 0.5µm, and has a pull-in voltage of 5.15V, which is verified by FEM simulation. In the second part we show a vertically aligned, multi gates device – Nanotube Field Effect Transistor with in-plane all-around outer and inner gate (Fig. 2). We show that the nanotube FET is capable of full volume inversion even with 40nm channel thickness, excellent electrostatic control and ballistic transport due to ultra-scaled Lg. Lithographic fabrication constraints are greatly relaxed compared to devices oriented parallel to the wafer surface owing to deposition thickness controlled gate length (Lg) definition, channel thickness scaling on the bulk Si, flexible channel orientation and in-situ formation of abrupt S/D junctions. A nanotube FET with 30 nm Lg and a channel thickness of 20 nm is capable of producing 2 mA/µm drive current, an SS of 66 mV/dec, a DIBL of 30.5 mV/V and an Ion/Ioff ratio of 107. These innovative devices present a new paradigm for parallel data processing and ballistic transport device study.

III. Device Concepts & Sensor/System Functionality

Tuesday Aug 30	Location: Room 474
Session III-B2	MOLECULAR-LEVEL PROBES
	Chair: John X.J. Zhang, University of Texas, Austin
10:25-10:50	CONTROLLING ELECTRONIC STATES AND TRANSPORT PROPERTIES OF MOLECULAR TRANSISTORS
Invited	Hyunwook Song, Yale University
10:50-11:10	A MODEL MOLECULAR ELECTRONICS SYSTEM: STYRENE ON THE SILICON (111)-7X7 SURFACE
	Robert Opila, University of Delaware
11:10-11:30	MECHANICALLY CONTROLLED NEAR-FIELD FLUORESCENCE EXCITATION WITH COLLOIDAL QUANTUM DOT LIGHT EMITTING DIODES
	Kazunori Hoshino, University of Texas-Austin
11:30-11:50	FABRICATION OF FUNCTIONAL CONDUCTIVE NANOFIBERS COMPOSED OF **α**,**ω**-bi-DNP-POLY (2-METHOXYSTYRENE), POLYSTYRENE INCLUDING SINGLE WALLED CARBON NANOTUBES FOR STUDYING MATERIAL-CELL INTERACTIONS AND GOLD NANOPARTICLE/SYNTHETIC FUNCTIONAL POLYMER NANOFIBERS FOR NANOBIOSENSORS
	Laurisa London, Clark Atlanta University
11:50-12:10	ONLINE ANALYSIS USING LABEL-FREE PARTICLE PLASMON RESONANCE IMMUNO-BIOSENSOR COUPLED WITH LIQUID CHROMATOGRAPHY MASS SPECTROMETRY
	Shau-Chun Wang, National Chung Cheng University-Taiwan
12:15-13:30	LUNCH BREAK: Main Hall
	NANOFORENSICS: NANOTECHNOLOGY FOR FORENSIC SCIENCE, VERIFICATION, AND VALIDATION APPLICATIONS
Lunch Keynote	James Klemic, The Mitre Corporation

III-B2. Molecular-Level Probes

CONTROLLING ELECTRONIC STATES AND TRANSPORT PROPERTIES OF MOLECULAR TRANSISTORS
Hyunwook Song, Mark Reed
Yale University

Electronic devices containing molecules as the active region have been an active area of research over the last few years. In molecular-scale devices, a longstanding challenge has been to create a true three-terminal device; e.g., one that operates by modifying the internal energy structure of the molecule, analogous to conventional FETs. Here we report the observation of such a solid-state molecular device, in which transport current is directly modulated by an external gate voltage. We have realized a molecular transistor made from the prototype molecular junction, benzenedithiol, and have used a combination of spectroscopies to determine the internal energetic structure of the molecular junction. Resonance-enhanced coupling to the nearest molecular orbital is revealed by electron tunneling spectroscopy, demonstrating for the first time direct molecular orbital gating in a molecular electronic device.

A MODEL MOLECULAR ELECTRONICS SYSTEM: STYRENE ON THE SILICON (111)-7X7 SURFACE
Conan R. Weiland, Liu Yang, Carl A. Menning, Dimitri Skliar, Brian G. Willis, Jingguang G. Chen, Douglas J. Doren, Robert L. Opila
University of Delaware-Newark, University of Connecticut-Storrs

Styrene on Si (111)-7x7 surfaces was investigated as a model molecular electronics system to study the effects of conjugation on charge transport to the semiconductor surface. Scanning tunneling microscopy (STM) imaging, combined with calculated images show that styrene binds in a [4+2] cycloaddition mode. The binding is through the terminal C of the vinyl substituent and a C on the phenyl ring to the Si surface. The distance between Si atoms on the (111)-7x7 surface drives this. This work demonstrates the applicability of STM as a probe of binding geometries for single molecules. These single molecule results are consistent with those of ensembles of molecules as obtained by high resolution electron energy loss spectroscopy (HREELS). For styrene on Si (111)-7x7, the aromaticity of the phenyl ring is broken and the conjugated p-system does not extend to the silicon surface, potentially hindering conduction between molecule and surface. However, styrene does retain a conjugated p- system after binding, as is evident in the p-p* shakeup transition, seen in the C 1s X-ray photoelectron spectra as well as UV photoemission spectra. This suggests that styrene-type molecules, unlike oligophenylyne ethynylene moieties, when bonded to Si surfaces, do not maintain ready conduction between molecule and surface.

MECHANICALLY CONTROLLED NEAR-FIELD FLUORESCENCE EXCITATION WITH COLLOIDAL QUANTUM DOT LIGHT EMITTING DIODES

Kazunori Hoshino, Ashwini Gopal, Micah Glaz, David Vanden Bout, Xiaojing Zhang
University of Texas-Austin

We demonstrate distance-controlled fluorescence excitation using electrically pumped colloidal quantum dots (QDs) as an excitation source and secondary colloidal QDs as a sample. We fabricated a monolayer colloidal QD light emitting diode (QDLED) at the tip of a scanning microprobe. The QDLED probe has been employed in a near-field scanning optical microscope to demonstrate nano-scale fluorescence excitation and imaging. The fluorescence intensity measurement showed 50 nm-scale sensitivity to the light source position, demonstrating our capability of mechanically controlled excitation. Here we demonstrate near-field fluorescence excitation, where a probe tip-embedded QDLED employed in a near-field scanning optical microscope (NSOM) directly excites a secondary colloidal QD sample.

FABRICATION OF FUNCTIONAL CONDUCTIVE NANOFIBERS COMPOSED OF **α**,**ω**-bi-DNP-POLY(2-METHOXYSTYRENE), POLYSTYRENE INCLUDING SINGLE WALLED CARBON NANOTUBES FOR STUDYING MATERIAL-CELL INTERACTIONS AND GOLD NANOPARTICLE/SYNTHETIC FUNCTIONAL POLYMER NANOFIBERS FOR NANOBIOSENSORS

Laurisa London, Omotunde Olubi, Darkeyah Reuven , Deepti Gadi, Biswajit Sannigrahi, Maher Atteya, Michael Williams, Ishrat Khan, Barbara Baird, Malik Mazaa
Clark Atlanta University, Cornell University, Georgia Perimeter College, iThemba LABS-S. Africa

Conductive fibers decorated with α,ω-bi-DNP (dinitrophenyl) groups capable of specifically binding with anti-DNP IgE have been prepared by electrospinning a solution of α,ω-bi-DNP-poly(2-methoxystyrene), polystyrene and single walled carbon nanotubes (SWCNT). The nanowires (200nm) were electrospun onto a silicon wafer substrate at a voltage of 10kV using either DMF or chlorobenzene. The bi-nitrophenyl (DNP)-functional groups were tethered to the fibers via oligo (oxyethylene) spacers. A (water and ethanol) solution consisting of poly (vinyl alcohol) and gold nanoparticles (AUNPs) were electrospun onto several substrates: glass, FTO, silicon, FTO on plastic and aluminum foil. The gold particle embedded fibers are being developed for photonic applications. The AUNPs (diameter ranged from between 3 - 43 nm in size) used in the preparation of the fibers were prepared by two methods: the liquid - liquid interface method and the one-phase synthesis technique. The α, ω-bi-DNP-poly (2-methoxystyrene) functional polymers were synthesized in the lab by first preparing the α, ω-di-hydroxyl-poly (2-methoxystyrene) by living anionic polymerization, followed by the functionalization of the di-hydroxyl polymer with the DNP functional group. The functional polymers have been characterized by 1H and 13C NMR, FT-IR, DSC, GPC, SEM, and TEM. Furthermore, we have also prepared conductive (based on polypyrroles) nanowire structures decorated with functional (DNP) groups capable of specifically engaging target anti- DNP IgE and IgE on mast cell surfaces. The binding affinity of nanowires containing 1% single-walled Carbon Nanotubes with anti-DNP IgE has been studied via fluorescently labeled FITC-IgE. The success achieved so far in this investigation suggests the possibility of developing functional nanofibers as the active component in biosensors.

ONLINE ANALYSIS USING LABEL-FREE PARTICLE PLASMON RESONANCE IMMUNO-BIOSENSOR COUPLED WITH LIQUID CHROMATOGRAPHY MASS SPECTROMETRY

Yu-Jane Huang, Chia-Yu Lee, Lai-Kwan Chau, Shau-Chun Wang
National Chung Cheng University-Taiwan

Unlike conventional immuno-biosensing technologies using fluorescence or radioactive detections which require chemical derivatives to tag detection markers, label-free detection using particle plasmon resonance, also known as localized surface plasmon resonance, on noble metal nano-particles is a simpler and less time-consuming method with less risk to alter the binding conjugation of immunoassays. Particle plasmon resonance (PPR) is therefore a suitable label-free optical detection method to develop microfluidic immuno-biosensor when least amount of sample consumption is preferable. In this paper, antigen functionalized gold nano-particles are coated on the cladding layer of a stripped optical fiber segment sealed in microchannel. Intensity attenuation of propagating light through the fiber is sensitive to the docking events with the molecular probes immobilized on the nano-particles. The relation of intensity attenuation versus target molecule concentration can be used to determine target molecules such as antibodies. Having been docked with biotion coated nano-particles on the cladding fiber segment in microchannel, strepavidin proteins are desorbed using hot waters to flush out off the microchannel to detect with liquid chromatography mass spectrometry (LC-MS) for secondary confirmation. Similarly, anti-ovalbumin antibody docked on the immobilized ovalbumin on the nanoparticles is washed with glycine buffer to desorb and to confirm with LC-MS.

IV. Materials, Fabrication and Integration for Sensor/System Architectures

Tuesday Aug 30	Location: Room 475
Session IV-A2	NOVEL MICRO/NANO-STRUCTURES FOR SENSING
	Chair: Mordechai Rothschild, MIT
10:25-10:50	DNA TRANSPORT IN NANOPARTICLE POROUS-WALL NANOCHANNELS
Invited	Steven Brueck, University of New Mexico
10:50-11:10	DIFFERENT METAL OXIDES MODIFIED ZNO NANOWIRE ARRAYS FOR HIGHLY SENSITIVE AND SELECTIVE GAS DETECTION
	Haiqiao Su, University of New Orleans
11:10-11:30	SWITCHABLE ADHESION ON DUAL NANOMETER AND MICRON STRUCTURED SURFACES FOR EFFICIENT AQUEOUS SAMPLE COLLECTION AND RECOVERY
	Theodore Fedynyshyn, MIT-Lincoln Laboratories
11:30-11:50	TAILORING OPTICAL RADIAITONS USING NANOPATTERNS
	Youngkyu Lee, University of Texas-Austin
11:50-12:10	OPTICAL NANOSENSORS
	Michael Strano, Massachusetts Institute of Technology
12:15-13:30	LUNCH BREAK: Main Hall
	NANOFORENSICS: NANOTECHNOLOGY FOR FORENSIC SCIENCE, VERIFICATION, AND VALIDATION APPLICATIONS
Lunch Keynote	James Klemic, The Mitre Corporation

IV-A2. Novel Micro/Nano-Structures for Sensing

DNA TRANSPORT IN NANOPARTICLE POROUS-WALL NANOCHANNELS

Yuliya Kuznetsova, Alexander Neumann, Ed Mendoza, Steven Brueck
University of New Mexico, Redondo Optics-CA

Electrokinetic DNA transport in nanochannels is investigated. Nanochannel dimensions were defined by interferometric lithography and fabricated by spin coating silica nanoparticles onto photoresist patterns. The pore dimensions are simply adjusted by changing the silica nanoparticles size. We observed DNA transport in 1D porous nanochannel structures, using capillary action (hydrophilic surface tension) and electrophoresis as driving forces. Transport was investigated in both the channel and the porous regions. Fluorescent DNA movement and extension in 1D channels as a function of an applied electric field is reported.

DIFFERENT METAL OXIDES MODIFIED ZNO NANOWIRE ARRAYS FOR HIGHLY SENSITIVE AND SELECTIVE GAS DETECTION

Haiqiao Su, Jiajun Chen, Kai Wang, Kun Yao, Weilie Zhou
University of New Orleans, LA

Three dimensional (3D) nanoarchitectures are attracting more attention recently for device and sensor fabrication because of their unique structures. In our former work, we mimicked the biological olfactory receptor array and demonstrated that SnO2 coated 3D ZnO nanowire arrays, modified with different noble metals, performed as highly sensitive and selective sensors for five different gases detection. However, for highly selective gas detection, fabrication of different materials nanowire arrays is essential. In this talk, we will present our recent research on exploring different metal oxides modified ZnO nanowire arrays for selective detection. In this experiment, In2O3, SnO2, and WO3 were sputtered on ZnO nanowire array surface as active materials, targeting at selective detection of H2S, NO2, CO, NH3, and H2. The gas sensors showed high sensitivity to H2S and NO2 down to part per billion (ppb) levels at room temperature, attributed to the large surface area of 3D structure. With principal component analysis (PCA) combined with the response speeds, different gases could be discriminated by this set of the nanowire arrays, which provides a potential method to prepare 3D highly sensitive and selective gas sensors using materials which are hardly grown as nanowire arrays.

SWITCHABLE ADHESION ON DUAL NANOMETER AND MICRON STRUCTURED SURFACES FOR EFFICIENT AQUEOUS SAMPLE COLLECTION AND RECOVERY

Theodore Fedynyshyn, Shaun Berry, Lalitha Parameswaran, Alberto Cabral
Lincoln Laboratory-MIT

All biological assays require effective sample collection and swabbing is the most commonly used sampling method, but the sample recovery from a standard swab is limited. Maximum adhesion to the target is typically ~ 50% and target recovery typically is only 20-40% with the target sample often diluted during recovery by 10-100X. High adhesion during sample collection often means poor final sample recovery. Dynamically switchable adhesion can independently optimize adhesion and recovery, potentially increasing overall assay performance. Toward this end, we have prepared textured surfaces containing dual nanometer and micron structures with differing surface treatments and have shown that certain unique combinations of the nanometer and micron structures exhibit electrically controlled switchable adhesion. This electrical switching changes the surface from hydrophobic or superhydrophobic to hydrophilic with a commensurate change in water adhesion. The use of textured surfaces to achieve superhydrophobicity is routinely found in nature. The best known example is the lotus plant, which has leaves that exhibit superhydrophobic, self-cleaning properties where water beads up into droplets and easily rolls off the leaves' surfaces. These leaves, as shown in Figure 1, have a double structure of micron sized nubs of about 20-40mm with nano-sized asperities superimposed and coated with a waxy layer for increased hydrophobicity. Interestingly, the rose petal, also shown in Figure 1, is also made up of dual micro and nano-scale structures of roughly the same scale as the lotus leaf, but its structures are arranged in such a way to allow water to bead up into droplets but instead of rolling off, the water droplets adhere to the surface, giving the petal a fresh look. This behavior inspired us to investigate a series of differing nanometer and micron structures as a possible means to control aqueous adhesion.

TAILORING OPTICAL RADIAITONS USING NANOPATTERNS

Youngkyu Lee, Kazunori Hoshino, John X. J. Zhang
University of Texas-Austin

We demonstrate enhanced optical directional radiation from a series of sub-wavelength-scale patterns on silicon surface, such as a slit-based nanostructure. Tailoring the direction of optical radiation can be achieved using the Huygens's principle. In this paper, directional optical radiation was demonstrated through manipulating wave fronts of scattered wave. We designed and fabricated a slit-grating nano-structure, where nanoscale gratings were co-fabricated next to the sub-wavelength scale slit. The directional radiation characteristic has been further improved by the unidirectional surface plasmonic wave generation to enhance slit-to-grating coupling efficiency. Both theoretical simulations and experimental verifications have been carried out showing directional radiation. The preliminary optical measurements were performed to characterize the far-field radiation pattern of the fabricated nanopatterns. Radiation angle of TM wave passing through the slit-grating nanostructure was varying from 7 to 20 degrees with respect to various wavelengths, 560nm, 580nm, and 633nm.

OPTICAL NANOSENSORS

Michael Strano
Massachusetts Institute of Technology

II. Sensor & Systems Applications

Tuesday Aug 30	Location: Main Hall
13:30-13:55	STRUCTURAL DNA NANOTECHNOLOGY: FROM NANOMATERIALS TO NANOROBOTS TO NANODIAGNOSTICS
Plenary	Nadrian Seeman, New York University
Session II-B	NANO-ENHANCED SENSITIVITY
	Chair: Osvaldo Oliveira, University of Sao Paulo, Brazil
14:10-14:35	MICROCAVITY BIOSENSING: RECENT ADVANCES
Invited	Frank Vollmer, Max Plank Institute, Germany
14:35-14:55	EXPERIMENTAL INVESTIGATION OF MASS SENSING WITH SURFACE ACOUSTIC WAVE DEVICES
	Frank MacDonald, U.S. Naval Surface Warfare Center
14:55-15:15	LOSSY MODE RESONANCES IN NANOCOATED OPTICAL FIBERS
	Ignacio del Villar, Public University of Navarra, Spain
15:15-15:40	SURFACE PLASMON RESONANCE BIOSENSING FOR DETECTION OF BACTERIAL PATHOGENS: STRATEGIES FOR ENHANCED SENSITIVITY
Invited	Jakub Dostalek, Austrian Institute of Technology
15:40-15:55	AFTERNOON BREAK (in front of Main Hall)

II-B. Nano-Enhanced Sensitivity

MICROCAVITY BIOSENSING: RECENT ADVANCES
Frank Vollmer
Max Plank Institute, Germany

Whispering-Gallery-Mode biosensors and optical-resonator derivatives have emerged as the most sensitive microsystem biodetection technology that does not require chemical amplification or labeling of the analyte. I will give an overview of recent advances in this area, which include the use of optical bistability in biosensing, coupling of WGMs to plasmonic nanoparticles, and the potential use of random microcavity nanolasers in biodetection. Nanoparticles are widely used in biosensing assays since their surface is easily modified for specific detection needs, and their size and spectral properties can be tailored for sensitive optical readout. We introduce a biosensing approach, which, for the first time, combines the high-sensitivity of whispering gallery modes (WGM) with a nanoparticle based assay. We quantitatively analyzed the binding of BSA proteins to gold nanoparticles from high-Q WGM resonance frequency shifts and find a Langmuir adsorption isotherm, which agrees with the theoretical predictions of a two-component adsorption model. We further propose to develop a miniature optical biosensor array where high sensitivity for detection of biomolecular interaction does not require a fluorescent label. In this label-free approach, non-linear frequency-shifts of optical resonators ('nanobeams') provide a digital all-or-nothing response to equilibrium binding of a biomarker to surface-immobilized bio-recognition elements. The threshold level for the digital response is adjustable to accommodate for varying receptor affinities, and under ideal conditions we project single molecule sensitivity. Furthermore, without the need for labels, digital detection of biomarkers can be done on-site and in real-time, an important advantage in emerging high-throughput point-of-care biosensing applications. The silicon nanobeam sensor has the potential to replace commercially available fluorescent-label based protein and gene chips since fabrication is inexpensive and amenable to mass-production by photolithography. We also demonstrate a design concept for obtaining lasing from Anderson-localized modes in disordered 2D photonic crystals and

photonic crystal waveguides with InAs quantum dots as gain medium. Structural disorder is present due to nanometer scale dislocation of lattice elements and causes multiple scattering of slow Bloch modes.

EXPERIMENTAL INVESTIGATION OF MASS SENSING WITH SURFACE ACOUSTIC WAVE DEVICES

Frank MacDonald, Guanshui Xu, Javier Garay, Junlan Wang
U.S. Naval Surface Warfare Center, University of California-Riverside, University of Washington

We present an experimental study of mass sensitivity for a Surface Acoustic Wave (SAW) sensor. Chemical SAW sensors have been developed to detect the mass variation of the mass adsorbed into sensing film by showing resonant frequency shifts. Previous experimental results have focused on the static sensitivity of theoretical SAW sensors assuming that the film thickness is negligible compared to the central wavelength of surface waves. Most current research is focused on dynamic experimental measurement and analytical techniques that are application specific. We have studied a SAW sensor with relatively thick isotropic film layers sputtered on as a static measurement comparison. The results can be used in a detection algorithm to quantify mass on the SAW sensor. Our results show a set of nodal response wave form changes and frequency shifts due to a continuous mass distribution. The development of the static experimental technique was completed with duplicate SAW tests. The duplicate SAWs had 12 measurements with 10 independently sputtered layers of 100 μm SiO_2, hermitically sealed, and hermitical seal removed using a HP8510A network analyzer. In addition, our results show the worst case total error of 0.1% between replicates. Further testing and modeling is required to correlate macro to micro scales for quantifying mass detection with SAW sensors.

LOSSY MODE RESONANCES IN NANOCOATED OPTICAL FIBERS

Ignacio Del Villar, Abian B. Socorro, Jesus M. Corres, Carlos R. Zamarreño, Miguel Hernaez, Ignacio R. Matias, Francisco J. Arregui
Public University of Navarra, Spain

The sensitivity to variations in the properties of the coating of a nanocoated non-tapered optical fiber and a nanocoated tapered optical fiber is compared, showing a ten-fold improvement when the diameter is reduced. The detection is based on the monitorization of dips in the transmission spectrum due to coupling of light from the optical waveguide to the coating, which is denominated as lossy-mode-resonance (LMR) Lossy Mode Resonances (LMRs) have been recently described by our group as a novel type of resonances that present several remarkable and interesting properties, such as the possibility to be obtained with both TE and TM polarized light or the possibility to generate multiple resonances. The platform used to obtain LMRs is based on the deposition of a nanometric-size thin-film on the cladding of an optical fiber. Light guided by the optical fiber is coupled to the thin-film region for specific combinations of light wavelength and coating refractive index and thickness.

SURFACE PLASMON RESONANCE BIOSENSING FOR DETECTION OF BACTERIAL PATHOGENS: STRATEGIES FOR ENHANCED SENSITIVITY

Jakub Dostalek, Chun Jen Huang, Yi Wang
Austrian Institute of Technology-Austria, Beijing Institute of Technology-China

Two novel schemes of surface plasmon resonance (SPR) biosensor for rapid detection of microbial pathogens with advanced sensitivity are reported. We show that by using long range surface plasmon-enhanced fluorescence spectroscopy (LRSP-FS), ultrasensitive detection of target analyte (E. *coli* O157:H7) can be achieved with the limit of detection <10 cfu/mL. In addition, we demonstrate an SPR biosensor that combines magnetic nanoparticle assays with LRSPs and takes advantage of overcoming the diffusion-limited binding kinetics and increasing the refractive index changes associated with the analyte capture on the sensor surface. The implementation of presented approaches for simultaneous analysis of multiple analytes present in real samples will be addressed.

II. Sensor & Systems Applications

Tuesday Aug 30	Location: Main Hall
13:30-13:55	STRUCTURAL DNA NANOTECHNOLOGY: FROM NANOMATERIALS TO NANOROBOTS TO NANODIAGNOSTICS
Plenary	Nadrian Seeman, New York University
	Location: Room 215
Session II-D	NANO-ENABLED IMAGING TECHNOLOGY
	Chair: Jeremy Zimmerman, U.S. Navy Research Laboratory (NRL)
14:10-14:35	USE OF NANO-STRUCTURED SURFACES TO ENABLE HIGHER RESOLUTION DETECTOR ARRAYS FOR LENSFREE IMAGING AND SENSING ON A CHIP
Invited	Aydogan Ozcan, University of California-Los Angeles
14:35-14:55	THE PEX-SENSORS SUITE FOR VISUALIZING SENSING AND BIOSENSING DATA
	Cristina Ferreira de Oliveira, University of São Paulo-Brazil
14:55-15:15	PHOTOLUMINESCENT SILVER NANOCLUSTERS FOR ADVANDCED BIOIMAGING
	Vira Kravets, University of Colorado
15:15-15:35	UNCOOLED NANOMETRIC SCALE BOLOMETER SYSTEM FOR THZ SENSOR ARRAY
	Aleksander Sesek, University of Ljubljana-Slovenia
15:40-15:55	AFTERNOON BREAK (in front of Main Hall)

II-D. Nano-Enabled Imaging Technology

USE OF NANO-STRUCTURED SURFACES TO ENABLE HIGHER RESOLUTION DETECTOR ARRAYS FOR LENSFREE IMAGING AND SENSING ON A CHIP

Bahar Khademhosseinieh, Ikbal Sencan, Gabriel Biener, Aydogan Ozcan
University of California- Los Angeles, California NanoSystem Institute-UCLA

We introduce the use of nano-structured metallic surfaces to significantly increase the effective pixel density of an opto-electronic detector-array. In this technique, the object field is directly projected onto a nano-structured thin metallic film that is composed of a set of sub-wavelength apertures, and the transmitted light from this chip, after being modulated by the nano-structures, diffracts over a short distance (e.g, 0.1-0.2mm) to be sampled by an opto-electronic detector-array without the use of any lenses. This detected diffraction pattern then permits rapid reconstruction of the projected object distribution on the chip at the sub-pixel level using a compressive sampling algorithm. We provide experimental proof of concept of this approach at both visible and infrared parts of the electromagnetic spectrum. This approach is especially important to advance the state of the art toolset in lensfree on-chip imaging and sensing technologies and could lead to better telemedicine microscopes and on-chip sensors that could even work in resource poor environments such as the battlefield.

THE PEX-SENSORS SUITE FOR VISUALIZING SENSING AND BIOSENSING DATA

Maria Cristina Ferreira de Oliveira, Rafael Mitsuo Maki, Gabriel Amorim de Coelho Silva, Fernando Vieira Paulovich
University of São Paulo-Brazil

We describe a software platform referred to as *PEx-Sensors*, aimed at supporting the visual exploration and analysis of sensing and biosensing data. The techniques available for creating data visualizations are described, as well as associated functionalities aimed at assisting data analysis. We address their applicability in the analysis of sensing and biosensing data, as suitable tools to support exploratory investigation of alternative sensor configurations. *PEx-Sensors* has been adapted from *PEx* the *Projection Explorer* software, which incorporates a variety of techniques for creating visual representations of high-dimensional data in general, such as collections of textual documents, collections of images. In particular, it incorporates multiple approaches to generate visual layouts of the high-dimensional data in a two-dimensional visual space, some of which have been inherited by *PEx-Sensors*. The resulting layouts, coupled with suitable interaction functions, enable visual analysis of data useful for exploring different scenarios and for decision making. Developed in Java to ensure portability, *PEX-Sensors* incorporates four distinct techniques to handle sensor data, namely Principal Component Analysis, a linear technique for dimension reduction that identifies linear combinations of the data attributes responsible for explaining most of the data variance; Sammon´s Mapping and Classical Scaling, both examples of non-linear multi-dimensional scaling techniques (generally known as MDS approaches; and IDMAP, a technique originally proposed for handling text data that works by generating an initial data layout with a fast dimension reduction technique which is then improved with a placement strategy that mimics a force directed placement approach.

PHOTOLUMINESCENT SILVER NANOCLUSTERS FOR ADVANDCED BIOIMAGING

Vira Kravets, Kyle Culhane, Igor Dmitruk, Anatoliy Pinchuk
University of Colorado-Colorado Springs, National Taras Shevchenko Kyiv University-Ukraine

We report solid-state thermal reduction synthesis and optical and structural characterization of novel photoluminescent probes for bio-imaging: glycine-coated silver nanoclusters. The silver nanoclusters exhibit multicolor size-dependent photo-luminescence in the visible spectral range. In terms of their small size, brightness and photostability, noble metal nanoparticles and nanoclusters hold the most promise as candidates for biological cell imaging, competing commonly used semiconductor quantum dots, fluorescent proteins and organic dyes. When applied to the problem of intracellular imaging, the metal nanoclusters offer advantages over their much larger sized semiconductor counterparts in terms of ease of biological delivery. In addition, noble metal nanoparticles and nanoclusters are photostable, and neither photobleaching nor photoblinking have being observed so far. The high quantum yield (QY) of the photoluminescence emission signal enables the isolation of the cluster's photo-luminescence from the cellular autofluorescence in cell imaging, improving the image contrast.

UNCOOLED NANOMETRIC SCALE BOLOMETER SYSTEM FOR THZ SENSOR ARRAY

Janez Trontelj, Marijan Ma**č**ek, Aleksander Se**š**ek, Andrej **Š**vigelj
University of Ljubljana-Slovenia

Nowadays, fast stand-off detection of weapons, exploding and hazardous materials become crucial in almost all civil regions. Therefore, movable, small and room temperature operation systems for stand-off detection are preferable in security units. The system presented in this paper operates at room temperature and provides basic THz sensory pixel for array formulation, used in stand-off detector systems. The system presents bolometer and antenna tuned on 0,3THz. On this frequency concealed weapons or explosives under several layers of different textiles or in bags, luggage etc., can be detected. With this technology demonstrator vision system which was also developed in our laboratory, hidden objects were detected up to 5m distance with 10mm resolution. The core of the pixel is a Titanium bolometer, with effective dimensions 88m x 400nm. The aim of the bolometer sensing system is the fabrication of the bolometer, which has a big temperature coefficient and it has minimal thermal conductivity to its surroundings.

IV. Materials, Fabrication and Integration for Sensor/System Architectures

Tuesday Aug 30	Location: Main Hall
13:30-13:55	STRUCTURAL DNA NANOTECHNOLOGY: FROM NANOMATERIALS TO NANOROBOTS TO NANODIAGNOSTICS
Plenary	Nadrian Seeman, New York University
	Location: Room 474
Session IV-B2	NANOFAB FOR SENSING & MONITORING
	Chair: Sarah Bedair, U.S. Army Research Laboratory (ARL)
14:10-14:35	INDUCED DEPOSITION MASK LITHOGRAPHY, A NOVEL APPROACH TO FABRICATE NANO OPTICAL ANTENNAE ON SCANNING PROBE TIPS
Invited	Alexander Weber-Bargioni, Lawrence Berkeley National Laboratories
14:35-14:55	A CHITIN NANOFIBER INK: REPLICA MOLDING, MICROCONTACT PRINTING, AND INKJET PRINTING
	Marco Rolandi, University of Washington-Seattle
14:55-15:15	ION-IMPLANTED OPTICAL CENTERS IN DIAMOND FOR NANOFABRICATION: DOSE DEPENDENCE AND CONVERSION EFFICIENCY OF Xe CENTER
	Anshel Gorokhovsky, CUNY/The College of Staten Island
15:15-15:35	FABRICATION OF SECURITY TAG PRINTS WITH COLLOIDAL QUANTUM DOTS
	Jian Xu, Penn State University
15:35-15:55	AFTERNOON BREAK (in front of Main Hall)

IV-B2. NanoFab for Sensing & Monitoring

INDUCED DEPOSITION MASK LITHOGRAPHY, A NOVEL APPROACH TO FABRICATE NANO OPTICAL ANTENNAE ON SCANNING PROBE TIPS

Alexander Weber-Bargioni, Stefano Cabrini
Lawrence Berkeley National Laboratories-CA

Here we present a novel approach for the fabrication of optical antennas and their combination with complementary devices such as Scanning Probe tips or photonic crystals. Optical antennas are one of the most promising ideas originating from the field of plasmonics, enabling highly efficient coupling between light and nanoscale objects. These optical antennas, recently made possible due to advances in nano fabrication techniques, are typically Au or Ag nanostructures with dimensions on the scale of 40 – 100 nm. They can be engineered with various geometries, with each exhibiting plasmon resonances at desired frequencies, allowing the electromagnetic coupling in the optical regime. Consequently, the Near Field created by the optical antenna exhibits high spatial resolution (as low as 10nm) and impressive intensities, allowing one to investigate optical properties of matter on unprecedented length scales. We applied IDML to fabricate reproducibly optical antennae on scanning probe tips for next generation near field probes to do sub-diffraction limited optical imaging and ultra sensitive sensing.

A CHITIN NANOFIBER INK: REPLICA MOLDING, MICROCONTACT PRINTING, AND INKJET PRINTING

Marco Rolandi, Adnan Kapetanovic, Chao Zhong, Yingxin Deng
University of Washington-Seattle

The ability to easily manufacture and manipulate biomaterials is key to the development of integrated biosensors. Harsh fabrication techniques derived from the semiconductor industry are often incompatible with biomaterials. Furthermore, these techniques do not take advantage of the natural self-assembly properties that can be exploited to create nanostructures. Chitin has attracted increased attention in biocompatible device fabrication. Chitin has excellent thermal stability, mechanical strength, biodegradability, and anti-microbial properties. However, chitin water insolubility has limited chitin nanofibers to electro spinning, which hampers nano- and microstructure fabrication. Here, we present a facile approach to chitin nano- and microstructures composed of self-assembled nanofibers. We have developed a hexafluoro 2-propanol (HFIP) based “chitin nanofiber ink”, which self-assembles into ultrafine (3nm) nanofibers upon drying. The chitin nanofiber ink is exploited to fabricate 2-D and 3-D structures via replica molding, microcontact printing, and inkjet printing. Examples include circles, squares, pillars, and optical gratings with features ranging from 100 nm to several microns. Microstructured biocompatible coatings for biosensors or integrated chitin biophotonic devices can be envisioned.

ION-IMPLANTED OPTICAL CENTERS IN DIAMOND FOR NANOFABRICATION: DOSE DEPENDENCE AND CONVERSION EFFICIENCY OF Xe CENTER

Yury Deshko, Alexander Zaitsev, Mengbing Huang, Anshel Gorokhovsky
The College of Staten Island, The University at Albany-The State University of New York

The ion implantation technique allows one to introduce into diamond different optical centers having emission lines in a broad spectral range, including near-infrared region. An advantage of the ion implantation as a doping technique is its high flexibility and precision in terms of impurity selection and concentration, as well as its 3D positioning. Focused ion implantation technique enables nanoscale patterning and may be used to fabricate single center optical emitters and optical carbon nanostructures for quantum information processing. On the other hand, ion implantation creates a number of radiation defects, which may affect optical and electrical properties of diamond. At a critical damage level, the diamond is converted into electrically conducting amorphous carbon. In this presentation we will report on photo- and electroluminescence studies of Xe-ion implanted diamond crystals. The luminescence spectra and intensity dependences on implantation dose within the wide dose range of 10^{10} – $5x10^{14}$ ion/cm^2 were investigated. The micro-luminescence confocal mapping and statistical analysis approach to determine the conversion efficiency of implanted Xe ions into emitting optical centers are discussed. Our interest in the Xe optical center originated from the fact that this center is one of a few (Ni, Si, Cr) in diamond having sharp emission lines in the infrared spectral region. Moreover, a diamond LED activated with Xe optical centers was demonstrated.

FABRICATION OF SECURITY TAG PRINTS WITH COLLOIDAL QUANTUM DOTS

Jian Xu, Andrew Wang, Jerzy Ruzyllo
Penn State University, OceanNanotech LLC

The results of an investigation of the feasibility of fabrication of security/anti-counterfeiting labels and barcodes with colloidal quantum dot inks using mist deposition technique are presented. This effort is geared toward the development of nanocrystal-based security tagging technology that in several aspects is superior to the existing technologies. Recently, there has been a worldwide effort in developing security-tag and anti-counterfeiting products with colloidal quantum dot (CQD) inks. This attempt roots from the marriage of the superior optical properties and the remarkable photochemical and thermal stabilities of the newly-developed semiconductor CQDs by virtue of the strongly quantum-confined electronic transitions in the nanoparticles as well as their unique core-shell configurations. In one example, CdSe/ZnS core-shell CQDs exhibit stable and size-tunable fluorescence with a quantum yield up to 95%. By tailoring the CQD size between 2-10nm, the luminescence emission is tunable over the entire visible and part of the near-infrared spectrum (450-700nm) with a very long lifetime (~10 years). These features render the CQDs appealing as the printable inks for a variety of applications, including advertising posters, anti-counterfeiting labels, and security identification. Moreover, our studies have recently uncovered similar optical and stability properties in some cadmium-free nanocrystals, such as ZnCuInSe CQDs, addressing environmental concerns with heavy metal (Cd) compositions.

IV. Materials, Fabrication and Integration for Sensor/System Architectures

Tuesday Aug 30	Location: Main Hall
13:30-13:55	STRUCTURAL DNA NANOTECHNOLOGY: FROM NANOMATERIALS TO NANOROBOTS TO NANODIAGNOSTICS
Plenary	Nadrian Seeman, New York University
	Location: Room 475
Session IV-B1	SENSING AT THE NANOSCALE
	Chair: Richard Claus, NanoSonic, Inc.
14:10-14:35	DETECTING ELECTROSTATIC POTENTIAL WITH NANOMETER RESOLUTION AND ITS APPLICATION FOR SENSOR DEVELOPMENT
Invited	Ida Lee, University of Tennessee
14:35-14:55	OXIDATION-REDUCTION REACTION OF CYTOCHROME *C* ON SOLID/LIQUID INTERFACES: *IN SITU* OBSERVATION BY TIME-RESOLVED SLAB OPTICAL WAVEGUIDE SPECTROSCOPY
	Naoki Matsuda, National Institute of Advanced Industrial Science & Technology-Japan
14:55-15:15	APTAMER BINDING TO SMALL ANALYTES: COMPARISON OF PERFORMANCE OF TWO APTAMERS KNOWN TO BIND TO POTASSIUM IONS
	Michael Stroscio, University of Illinois-Chicago
15:15-15:35	EXTREME ULTRAVIOLET NANOSPECTROMETY IMAGING FOR SINGLE CELL COMPOSITION MAPPING
	C.S. Menoni, Colorado State University
15:35-15:55	AFTERNOON BREAK (in front of Main Hall)

IV-B1. Sensing at the Nanoscale

DETECTING ELECTROSTATIC POTENTIAL WITH NANOMETER RESOLUTION AND ITS APPLICATION FOR SENSOR DEVELOPMENT

Ida Lee
University of Tennessee-Knoxville

Bacterial spore adhesion to inert surfaces is generally believed to involve surface hydrophobicity, surface polarity, surface electrical charge, and van der Waals (vdW) interactions. Although spores are known to attain electrostatic charge on their surface, previous experiments were conducted using a *Bt* spore and a gold substrate at conditions for which the electrostatic force could be ignored as a component of the adhesion force. Theoretical and experimental results were comparable for a *Bt* spore and the gold surface system. The measurements between the *Bt* spore and a mica surface showed a significant deviation from calculated results, which is believed to be due to the electrostatic force. This indicated that electrostatic force plays an important part in particle adhesion. In a recent study, we found out that the electrostatic force, including Coulombic and image forces, can account for up to 40% of the total adhesion force between a bacterial spore and a planar surface.

OXIDATION-REDUCTION REACTION OF CYTOCHROME *C* ON SOLID/LIQUID INTERFACES: *IN SITU* OBSERVATION BY TIME-RESOLVED SLAB OPTICAL WAVEGUIDE SPECTROSCOPY

Naoki Matsuda
National Institute of Advanced Industrial Science & Technology-Japan

In situ UV-vis. absorption spectra of cytochrome *c* adsorbed on ITO electrode was observed by slab optical waveguide spectroscopy with combining pulse potential step (PPS) between 0.3 and -0.45 V vs Ag/AgCl. The amount of cytochrome *c* adsorbed on ITO electrode was estimated by cyclic voltammogram to be about 60 % of a monolayer coverage in this experimental condition. Spectral change between oxidized and reduced cytochrome *c* by PPS was finished in about 20 or 40 msec with phosphate buffer solution. By use of diluted PBS it took longer time to complete ET reaction. The heme proteins are one of the most important molecules in biochemistry and biotechnology. Cytochrome *c* (cyt. *c*) has been probably most extensively studied by a number of researchers for understanding their functionality. We have developed a novel technique using slab optical waveguide (SOWG) spectroscopy, with which absorption spectra in UV-visible light region from adsorbed molecules below a monolayer coverage were observed. Using indium-tin-oxide (ITO) electrode thin film on a SOWG (ITO-SOWG), in situ observation of molecules adsorbed on electrode surface can be performed under electrochemical condition. We have already reported some results about in situ observation of adsorption process, reactivity, and electron transfer reaction of cyt. *c* by SOWG spectroscopy and electrochemical techniques. In this presentation, I will show the results about the functionality of cyt. *c* adsorbed on solid/liquid interfaces.

APTAMER BINDING TO SMALL ANALYTES: COMPARISON OF PERFORMANCE OF TWO APTAMERS KNOWN TO BIND TO POTASSIUM IONS

Michael Stroscio, Mitra Dutta, TsaiChin Wu
University of Illinois-Chicago

In this study, a comparison of the performance of two DNA-based aptamers is accomplished using quantum dots and nano-quenchers to monitor the conformational changes in the apatamers upon binding to small analytes – in this case potassium ions. These studies complement previous studies on the Raman spectra of such apatmers and they provide the basis for another tool in antibody-free analyte detection. TBA (5' GGT TGG TGT GGT TGG 3' and AG3 (5' GGG TTA GGG TTA GGG TTA GGG 3') are the two aptamers compared in this analysis. Speficically, TBA is the thrombin-binding aptamer that naturally existed and was found to have higher affinity to thrombin in 1993. It binds to alpha-thrombin and play important roles in blood-clotting processes. TBA is also the first aptamer that was studied widely. This sequence was reported to bind with potassium ions 30 times tighter than it does to sodium ion. Indeed, there are many works utilizing TBA as a potassium probe [3-7]. Herein, the TBA sequence is compared with AG3 (5' GGG TTA GGG TTA GGG TTA GGG 3') , which is a sequence part of the human chromosome telomere. It consists of four GGG sequences and is observed to fold and stabilize specifically by potassium ions because of its size and charge. It was therefore utilized to build the potassium sensing probe because of its high affinity to potassium ions. These aptamers are compared and the performance of these two sequences is discussed in terms of the potential applications of these probes for small-analyte detection. Herein, these aptamer beacons are compared under the conditions that the potassium level is in the range of (a) 0 to 4 mM, and (b) 5 to 80 mM.

EXTREME ULTRAVIOLET NANOSPECTROMETY IMAGING FOR SINGLE CELL COMPOSITION MAPPING

C.S. Menoni, J. Filevich, I. Kuznetzov, F. Dong, E.R. Bernstein, J.J. Rocca, A. Sakdinawat, Y. Liu, D.T. Attwood, D. Crick
Colorado State University, University of California-Berkeley

Mass spectrometry imaging (MSI) has played a vital role in the direct examination of the chemical composition of complex biological samples. MSI can produce images of the chemical composition of cells and tissue with spot sizes that are limited to 10-20 mm. The main limitation of MSI to image single cells is in the inability to focus to smaller spot the visible and ultraviolet laser illumination that is used to ablate the specimen. We will report on the implementation of a novel imaging mass spectrometry nanoprobe that uses extreme ultraviolet (EUV) laser illumination. When focused on carbon containing materials, the 46.9 nm wavelength EUV laser light creates by ablation holes with ~80 nm diameter. The ability of the EUV laser illumination to efficiently ionize the ablation fragments also allows to generate signature ions, that when detected using mass spectrometry identify the chemical composition of the ablated region.

II. Sensor & Systems Applications

Tuesday Aug 30	Location: Main Hall
Session II-B	NANO-ENHANCED DISCRIMINATION
	Chair: James Jensen, U.S. Army Edgewood Chemical & Biological Center (ECBC)
15:55-16:20	USE OF INFORMATION VISUALIZATION TO ENHANCE THE PERFORMANCE OF NANOTECH-BASED SENSING AND BIOSENSING
Invited	Osvaldo Oliveira Jr., Instituto de Física de São Carlos-Brazil
16:20-16:40	REPLACEMENTS AND ALTERNATIVES FOR DNA THAT IMPROVE SENSITIVITY AND MULTIPLEXING OF DNA-TARGETED DETECTION
	Shuichi Hoshika, Firebird Biomolecular Sciences LLC
16:40-17:00	SEPARATION AND DISCRIMIATION OF SERS COMPONENT SPECTRA FROM A MIXURE SAMPLE USING INDEPENDENT COMPONENT ANALYSIS AND SILVER NANOROD SUBSTRATES
	Justin Abell, University of Georgia
17:00-17:20	CARBON NANOTUBE- BASED INFRARED IMAGING SYSTEM
	Ning Xi, Michigan State University
17:20-17:40	MULTI-SIGNAL PROCESSING BIOSENSORS AND BIOACTUATORS BASED ON BIOCOMPUTING CONCEPT: TOWARDS 'SENSE-AND-ACT' INTEGRATED SYSTEMS FOR BIOMEDICAL APPLICATIONS
Invited	Evgeny Katz, Clarkson University
18:30-20:30	POSTER SESSION: Main Hall

II-B. Nano-Enhanced Discrimination

USE OF INFORMATION VISUALIZATION TO ENHANCE THE PERFORMANCE OF NANOTECH-BASED SENSING AND BIOSENSING
Osvaldo Oliveira Jr.
Instituto de Física de São Carlos-Brazil

The molecular control afforded by fabrication methods such as the Langmuir-Blodgett (LB) and layer-by-layer (LbL) techniques has led to unprecedented sensitivity and selectivity in sensors and biosensors whose sensing units are made of nanostructured films. Though primarily conceived to produce organic films, these techniques allow for hybrid organic-inorganic films to be obtained, where synergy is achieved through combination of various materials, including polymers, polysaccharides, metallic nanoparticles, carbon nanotubes and biomolecules. For biosensing, in particular, enzymes, DNA, antigens and antibodies may be immobilized with preserved activity, probably owing to the suitable scaffolding materials and to the entrained water in the films. High selectivity can then be achieved upon exploiting molecular recognition processes, as in antigen-antibodies pairs. The principles of detection used in nanotech-based sensors include electrochemical measurements, impedance spectroscopy, fluorescence spectroscopy and surface-enhanced Raman scattering (SERS). In some cases, sensor arrays are employed to improve the distinguishing ability for very similar samples, as is the case of electronic tongues and noses. In all these sensing systems a large amount of data are generated which demand treatment with statistical methods, but normally most of the data are simply discarded due to the difficulty in handling and interpretation. This scenario may change completely in the next few years with the introduction of information visualization that is suitable to handle large amounts of data. In this lecture, examples will be given of biosensors that had their performance enhanced considerably with multidimensional projection techniques and non-linear methods to project the data on a 2D plot.

REPLACEMENTS AND ALTERNATIVES FOR DNA THAT IMPROVE SENSITIVITY AND MULTIPLEXING OF DNA-TARGETED DETECTION
Steven Benner
Firebird Biomolecular Sciences LLC-FL

DNA sequences are the touchstone for identifying pathogens. Different DNA sequences distinguish pathogenic organisms from related non-pathogens. DNA sequences distinguish natural from engineered pathogens. DNA sequences define drug resistance and other factors to guide therapy. Further, the polymerase chain reaction (PCR) allows, in principle, analysis of single molecules of DNA. Last, also in principle, multiplexing of DNA analysis should be simple, given the rules that, at least at a textbook level, define DNA pairing. Unfortunately, realities are different from principles. In reality, chemical behaviors intrinsic to DNA, and complications intrinsic to complex biological samples, both make it impossible to obtain the selectivity, sensitivity and multiplexing that DNA might offer. The Benner group has developed a range of reagents that manage these realities. These include: (a) Self-avoiding molecular recognition systems (SAMRS). SAMRS supports high levels of multiplexing in the detection of DNA analytes, (b) Artificially expanded genetic information systems (AEGIS). AEGIS supports extremely clean capture of DNA targets from complex biological mixtures, and (c) Reversible terminators. These allow high discrimination between nearly identical sequences. This talk will outline of how reagent innovations today support novel sensing devices by themselves and as part of larger system concepts. They remain underexplored in military applications, even though they could be used as parts advanced sensors on many platforms, and should enhance performance in terms of cost, sensitivity, resolution, speed, lifetime, robustness, contamination, rate of false positives, range for detection, energy requirements, size, portability and simplicity of operation.

SEPARATION AND DISCRIMIATION OF SERS COMPONENT SPECTRA FROM A MIXURE SAMPLE USING INDEPENDENT COMPONENT ANALYSIS AND SILVER NANOROD SUBSTRATES

Justin Abell, Joonsang Lee, Qun Zhao, Yiping Zhao
University of Georgia-Athens

The potential for utilizing surface-enhanced Raman spectroscopy (SERS) as an ultrasensitive, label-free, and highly specific chemical sensing platform has obtained a significant amount of research attention recently. The powerful analytical merits that SERS provides are attracting the interest of researchers working on improving chemical detection capabilities within clinical, industrial, defense, and forensic sectors. However, before SERS can be employed as a sensing platform for real-world detection scenarios, certain obstacles must be overcome, namely the sampling and data processing. Traditionally, SERS has been employed for analysis of relatively pure samples in a well defined medium; however, biologically-relevant samples, such as blood or sputum, contain a mixture of components, and the resulting SERS spectra can be very complicated compared to those of pure analytes. How to obtain information about individual analyte(s) from the complex SERS spectra and quantify the relative composition is a very challenge yet very urgent task for SERS community. So far, there are only a limited number of reports in the literature discussing analysis of mixtures. To obtain information on individual component, a blind source separation method called independent component analysis (ICA) has been used. In this paper, a microliter-sized droplet of an artificial mixture of two analytes, trans-1,2-bis(4-pyridyl) ethylene (BPE), and 4-hydroxy thiophenol (i.e. mercaptophenol, MPh) at low, equimolar concentrations, is applied to highly sensitive and uniform Ag nanorod (AgNR) array SERS substrates.

CARBON NANOTUBE- BASED INFRARED IMAGING SYSTEM

Bo Song, Ning Xi, Hongzhi Chen, King Wai Chiu Lai, Liangliang Chen
Michigan State University

Carbon nanotubes (CNTs) have excellent optoelectronics properties because of their dimension structure. CNT based-infrared (IR) detectors have many advantages such as low dark current, low noise equivalent temperature difference, fast response and so forth. In addition CNT-based IR detectors have ability to sense middle-wave infrared (MWIR) signal without cooling system. This unique property realizes the dream of making IR detectors with detecting wavelength of 3-5 micron meter (middle-wave IR), work at room temperature. However, due to the limitation of fabrication process and the ultra small dimension of CNTs, it is difficult to fabricate large sensing cells of this kind of IR detector. That prevents the coming out of CNT-based IR cameras. Compressive sensing provides a solution for this problem. Compressive sensing firstly comes out with fewer measurements needed than the limitation of Nyquist-Shannon sampling rate. It keeps almost all information of observed signal if this signal is sparse. Instead of acquiring the entire signal, compressive sensing samples a sum of linear projections from original observed signal to measurement matrix. This measurement principle provides the way for making a single pixel IR camera. In this camera only one CNT-based IR detector is used. In this paper, a CNT- based single pixel IR camera is introduced and discussed. Moreover, the experiment results show that the performance of the IR camera works very well at room temperature.

MULTI-SIGNAL PROCESSING BIOSENSORS AND BIOACTUATORS BASED ON BIOCOMPUTING CONCEPT: TOWARDS ‘SENSE-AND-ACT’ INTEGRATED SYSTEMS FOR BIOMEDICAL APPLICATIONS

Evgeny Katz, Joseph Wang, Jan Halámek
Clarkson University, University of California-San Diego

We outline the conceptual foundations of the novel approach to biosensing based on multistep processing of biochemical signals through biocatalytic/biorecognition processes, adapting ideas recently developed in the field of biocomputing (biomolecular logic). Signal processing performed by biochemical means can be followed by transduction of the output chemical signals to the final electronic signals by electrochemical or optical methods. Signal processing by the enzyme-logic gates and their networks was used to switch nanostructured signal-responsive materials between different states, thus allowing transduction of chemical output signals into changes of material properties. The coupling between signal processing and stimuli-switchable systems was achieved by pH changes generated *in situ*. Logic operations performed by the enzyme systems were coupled with the reversible transition of polymer-modified electrodes to activate/deactivate bio-electrocatalytic reactions at sensing interfaces. The pH changes governing the interfacial properties were produced *in situ* in bulk solutions or locally directly at the modified surface. The developed approach resulted in the switchable sensing interfaces, e.g. switchable membranes activated on demand by signals received from the enzyme logic systems. Various bioelectronic devices with built-in Boolean logic were developed including “smart” biofuel cells, biomolecular keypad lock systems, biomedical sensors and biochemical actuators. “Smart” signal processing systems were scaled down to microsize utilizing a single microparticle for processing biomolecular signals according to built-in logic program. Particular attention will be given to the recently developed biomolecular logic systems for analysis of biomarkers characteristic of various injuries. Logically processed complex patterns of biomarkers allow unambiguous conclusion about kind of injury and offer a closed loop ‘Sense-and-Act’ operation upon integration with switchable drug-release systems. The resulting digital biosensors would benefit diverse and important fields that require immediate intervention or corrective action on the basis of reliable analytical data, ranging from biomedical applications and environmental monitoring to homeland security.

IV. Materials, Fabrication and Integration for Sensor/System Architectures

Tuesday Aug 30	Location: Room 215
Session IV-S2	NANOSCALE LASER & PHOTONIC SYSTEMS
	Chair: Michael Gerhold, U.S. Army Research Office (ARO)
15:55-16:20	SELF-ORGANIZED III-V SEMICONDUCOTOR MICROTUBE AND NANOWIRE LASERS AND INTEGRATED DNA SENSORS ON A SILICON PLATFORM
Invited	Zeitan Mi, McGill University-Canada
16:20-16:40	ACTIVE AND PASSIVE NANOPHOTONICS FOR SENSING SYSTEMS APPLICATIONS
Invited	Y. Fainman, University of California-San Diego
16:40-17:00	RECENT PROGRESS IN SUBWAVELENGTH PLASMONIC NANOLASERS AND POSSIBLE APPLICATIONS FOR SENSING AND DETECTION
	Cun-Zheng Ning, Arizona State University-Tempe
17:00-17:20	A MODULATED DUAL LASER SCHEME FOR REMOVING FLUORESCENCE FROM A RAMAN SPECTRUM
	Ravi Verma, Spectral Platforms Inc
17:20-17:45	ULTRASENSITIVE DETECTION WITH PLANAR OPTOFLUIDIC SYSTEMS
Invited	Holger Schmidt, University of California-Santa Cruz
18:30-20:30	POSTER SESSION: Main Hall

IV-S2. Nanoscale Laser & Photonic Systems

SELF-ORGANIZED III-V SEMICONDUCOTOR MICROTUBE AND NANOWIRE LASERS AND INTEGRATED DNA SENSORS ON A SILICON PLATFORM

Zetian Mi, Pablo Bianucci, Kai Cui, Md Golam Kibria, Yoshihiko Nagai, Rob Sladek
McGill University-Canada

We report on the recent progress on III-V semiconductor based nanoscale DNA sensors, with the use of single InN nanowires as well as self-organized InAs quantum dot microtubes on a silicon platform. We first describe the design, epitaxial growth, fabrication and characterization of InAs quantum dot microtube and single InN nanowire based lasers, which can exhibit a remarkably low threshold of ~ 4 μW at room temperature and emission wavelengths in the range of 1.2 to 1.8 μm. The functionalization of such nanoscale devices is realized using organosilane linkers through covalent bonding to surfaces, which is confirmed by XPS measurements. Moreover, the DNA-hybridization on InN nanowires is directly imaged using SEM by binding gold nanoparticles onto the functionalized surface. We have further investigated the catalyst-free growth of InN nanowire heterostructures on Si, which can exhibit, for the first time, nontapered surface morphology and nearly intrinsic properties. Unique to InN nanowires is the presence of surface electron accumulation, which promises significantly improved detection sensitivity when designed as field-effect-based biosensors.

ACTIVE AND PASSIVE NANOPHOTONICS FOR SENSING SYSTEMS APPLICATIONS

Y. Fainman, O. Bondarenko, A. Simic, A. Mizrahi, V. Lomakin, Q. Gu, J. Lee, M. Khajavikhan, B. Slutsky, M. Nezhad
University of California-San Diego

Achieving the goal of dense of photonic integration requires miniaturization of all photonic materials, devices and subsystems, including passive components (e.g., engineered composite metamaterials, filters) and active components (e.g., lasers). Dielectric materials have been commonly used in the past, but their modal structure does not permit to scale to mode scales well beyond the wavelength of radiation at which they are being operated. In contrast, plasmonic effects in metal-dielectric composites possesses unique physical properties that enable localization of optical fields beyond the diffraction limit set by the wavelength of electro-magnetic radiation. These highly confined/nanoscale optical modes will enhance light/matter interactions in systems with free electrons in micro/nanoscale geometric structures. New applications and devices that are expected to directly benefit from these light confined modes include biochemical sensors (SERS, SECARS), optical nonlinearities (SHG, etc.), near field probes and data storage, nanoscale lasers, and interconnects. Metal-dielectric interfaces support surface plasmon polaritons (SPPs). For properly chosen parameters, the effective index of the SPP modes can be considerably higher than the index of the surrounding dielectric media and therefore localize the optical fields in a nano-scale volume near metals. However, plasmonic modes are lossy and do not propagate over long distances. We conducted a study of an interface between metal and dielectric with gain and derived conditions for various SPP operation regimes. This work led to investigate numerous active plasmonic and plasmon-assisted metal dielectric structures and devices. As an example we will describe a metal-dielectric nanoresonator with gain allowing to achieve lasing action at room temperature with a total volume less than the wavelength of its radiation in all three dimensions.

RECENT PROGRESS IN SUBWAVELENGTH PLASMONIC NANOLASERS AND POSSIBLE APPLICATIONS FOR SENSING AND DETECTION

Cun-Zheng Ning
Arizona State University-Tempe

This talk will review the recent progress in nanophotonics, especially in making nanolasers that have dimensions smaller than the wavelengths involved. These lasers are made of semiconductor nanowires or nanopillars. Further size reduction is enabled by encasing nanopillars in metallic (plasmonic) shells. Possible applications of such nanolasers in detection and sensing will be discussed.

A MODULATED DUAL LASER SCHEME FOR REMOVING FLUORESCENCE FROM A RAMAN SPECTRUM

Ravi Verma
Spectral Platforms Inc.-CA

Raman scattering is an important analytical method that is being considered for a variety of important applications, such as the standoff detection of trace explosive residues. Unfortunately, the Raman spectrum is generally corrupted by a strong background fluorescence that must be removed before the Raman spectra can be usefully analyzed. Current methods for fluorescence removal involve fitting the data, but this only works for spectrum with large signal to noise ratios. Hardware methods for fluorescence removal include the use of gating schemes, and the use of deep UV lasers (lamda < 250 nm), but these tend to be very expensive and bulky solutions. We are proposing a compact hardware-algorithm combination that can efficiently remove fluorescence from a Raman spectrum. Our solution invokes two closely spaced laser line sources, with one source being modulated, and a special algorithm that exploits the modulation to efficiently remove the fluorescence background. Our simulations indicate that our method remains accurate at very large noise levels, and compares favorably to previous fluorescence removal methods. Our methods can be implemented with a pair of coupled nano lasers, thereby affording a low cost, and compact solution to the problem of fluoroscence removal.

ULTRASENSITIVE DETECTION WITH PLANAR OPTOFLUIDIC SYSTEMS

Holger Schmidt
University of California-Santa Cruz

I will review planar optofluidic approaches to ultrasensitive detection in liquids and gases. Hollow-core waveguide technology and their use for detection of bioparticles such as single viral pathogens and ribosomes will be reviewed. The opportunities and challenges to create complete optofluidic systems that include laser sources, fluidic handling and optical signal processing will be discussed.

III. Device Concepts & Sensor/System Functionality

Tuesday Aug 30	Location: Room 474
Session III-A1	MICRO-TO-NANOSCALE CHARACTERIZATION
	Chair: Brian LeRoy, University of Arizona
15:55-16:20	NANOSTRUCTURE-ENHANCED LASER TWEEZERS
Invited	Cameron Simmons, University of Washington
16:20-16:40	"GREEN" SYNTHESIS OF GOLD NANOPARTICLES AND THEIR USE AS BIOSENSOR SIGNAL AMPLIFIERS IN ANTHRAX AND TB DETECTION
	Evangelyn Alocilja, Michigan State University
16:40-17:00	DEVELOPMENT OF TECHNIQUES FOR ENCAPSULATION AND SCANNING ELECTRON MICROSCOPY OF FULLY HYDRATED MICRO-SAMPLES FOR FORENSIC APPLICATIONS
	Andrei Kolmakov, Southern Illinois University-Carbondale
17:00-17:20	DOUBLY CORRUGATED SPOOFED SURFACE PLASMON POLARITON (DC-SSPP) STRUCTURES WITH FREQUENCY SELECTIVE TRANSMISSION
	Zhao Xu, University of Michigan
17:20-17:45	APTAMER FUNCTIONALIZED MICROCANTILEVER (MC) BASED SENSING APPROACH FOR CONTROLLED SUBSTANCES
Invited	Pranav Shrotriya, Iowa State University-Ames
18:30-20:30	POSTER SESSION: Main Hall

III-A1. Micro-to-Nanoscale Characterization

NANOSTRUCTURE-ENHANCED LASER TWEEZERS
Cameron Simmons, Lih Y. Lin
University of Washington

The manipulation of small particles is crucial for many biological and biomedical applications. A popular method of achieving such control is optical tweezers. Conventional optical tweezers require tightly focused laser radiation with high intensity because the energy conversion from optical to mechanical is very inefficient. This high intensity is undesirable because it can damage biological specimens and prevent the in situ manipulation and monitoring of these specimens. One method to reduce this required intensity is through the use of plasmonic and photonic crystal nanostructure substrates that can enhance the field at the trap location. Our group has demonstrated low intensity trapping and rotation of micro- and nano-particles, nanowires and biological specimens through the utilization of nanostructure-enhanced laser tweezers.

"GREEN" SYNTHESIS OF GOLD NANOPARTICLES AND THEIR USE AS BIOSENSOR SIGNAL AMPLIFIERS IN ANTHRAX AND TB DETECTION

Evangelyn Alocilja, Edith Torres-Chavolla, Michael Anderson, Lilia Fernando
Michigan State University

Gold nanoparticles (AuNPs) are used in sensing approaches as signal amplifiers and attachment platforms. Common synthesis techniques utilize acidic conditions. Alkaline synthesis can be used as an environmentally friendly 'green' alternative to the Brust and Turkevich techniques. This alkaline technique uses dextrin as a capping and reducing agent for chloroauric acid. In this paper, we will present the alkaline method to AuNP production. Preliminary results show that the generated particles are highly dispersed and water soluble with a range of controllable mean diameters from 5.9 to 16.8 nm ± 1.6 nm. Stability in water exceeds 12 months when stored at room temperature (23°C) without protection from light. AuNP functionalization efficiency is similar to citrate-generated particles. Effects from variation in temperature, pH, and dextrin concentration on AuNP size will be discussed. The use of alkaline AuNPs as signal amplifier in anthrax and tuberculosis detection will be demonstrated.

DEVELOPMENT OF TECHNIQUES FOR ENCAPSULATION AND SCANNING ELECTRON MICROSCOPY OF FULLY HYDRATED MICRO-SAMPLES FOR FORENSIC APPLICATIONS

Andrei Kolmakov
Southern Illinois University-Carbondale

Many of the forensic samples are wet or toxic and require their collection and preservation for extended period for later studies. Scanning electron microscopy (including the environmental SEM) is one of the key imaging and analytical tools used which, however, capable to work with dried samples. Based on recent advancements of WETSEM technology and progress in fabrication of new electron transparent membranes here we report on development of new techniques for encapsulation and SEM of fully hydrated microscopic samples for forensic applications.

DOUBLY CORRUGATED SPOOFED SURFACE PLASMON POLARITON (DC-SSPP) STRUCTURES WITH FREQUENCY SELECTIVE TRANSMISSION

Zhao Xu, Pinaki Mazumder
University of Michigan-Ann Arbor

We studied the Doubly Corrugated Spoofed Surface Plasmon Polariton (DC-SSPP) structures aimed at THz applications. Frequency selectivity of those structures is verified in simulations. Both full field analysis and commercial simulation software are used to verify the results. There has been an ever increasing interest in developing THz devices and circuits in recent years, due to their great potential in sensor and detector applications. Compared with millimeter devices, THz devices utilize higher frequency, typically 0.1-3THz, to realize higher bit sampling rate and broader bandwidth. They also have the potential of eliminating the bulk and complexity of Quantum Cascade Laser (QCL) devices working in far-infrared spectrum.

APTAMER FUNCTIONALIZED MICROCANTILEVER (MC) BASED SENSING APPROACH FOR CONTROLLED SUBSTANCES

Kyungho Kang, Aaron Kempema, George Kraus, Marit Nilsen-Hamilton, Pranav Shrotriya
Iowa State University-Ames

Aptamer functionalized MicroCantilever (MC) based sensors can provide revolutionary sensitivity and specificity for forensic detection and identification of controlled substances, toxic species, biological molecules and DNA matching. Current sensor systems for controlled substances such as immunoassays and gas chromatography and mass spectrometry (GC-MS) require extensive sample preparation and/or specialized instrumentation to identify molecules of controlled substances such as cocaine and its metabolites with high specificity and sensitivity. In this work, we report a microcantilever based novel sensing mode for cocaine detection that achieves same detection threshold as immunoassays but in much shorter time.

III. Device Concepts & Sensor/System Functionality

Tuesday Aug 30	Location: Room 475
Session III-C1	FUNCTIONALIZED ORGANIC-INORGANIC INTERFACES FOR BIOSENSING
	Chair: Jean Pierre Leburton, University of Illinois
15:55-16:20	ORGANIC-CMOS INTERFACES
Invited	Jorge Seminario, Texas A&M University
16:20-16:40	SINGLE-MOLECULE SENSING WITH A NANOPORE: INSPIRATIONS FROM NATURE
	Liviu Movileanu, Syracuse University
16:40-17:00	CURRENT MODULATION BY DNA TRANSLOCATION THROUGH A CARBON NANOELECTRODE-INSTRUMENTED NANOPORE
	Scott Collins, University of Maine
17:00-17:20	HYBRID BIOLOGICAL-SOLID-STATE CIRCUITS BASED ON INTEGRATED, SOLID-SUPPORT LIPID BILAYERS
	Kenneth Shepard, Columbia University
17:20-17:45	ELECTRICALLY TUNABLE DNA TRANSLOCATION THROUGH A NANOPORE IN A MULTILAYERED SEMICONDUCTOR MEMBRANE
Invited	Maria Gracheva, University of Illinois
18:30-20:30	POSTER SESSION: Main Hall

III-C1: Functionalized Organic-Inorganic Interfaces for Bio-Sensing

ORGANIC-CMOS INTERFACES
Jorge Seminario
Texas A&M University-College Station

We present results of our theory-guided approach to a carbon-based electronics able to interface to the traditional CMOS Silicon technology, allowing standard electronics to take advantage of the advances in nanotechnology, producing the smoothest transition between these two key technologies. We will focus on electron-intrinsic characteristics to carry and process information in graphene- or organic-based devices. In turn, electron charge can be used in the traditional current-voltage scenario or under new ones, molecular potentials and vibronics that we have implemented in recent years. Organic molecules supported on graphene and interfaced to silicon-based electronics are able to withstand ion bombardment up to seven times longer than expected; this kind of nanostructure is naturally resistant to damage caused by ionizing radiation. Molecular simulations are performed to analyze possible microscale structural damage induced by exposure to ion irradiation. Electrical measurements allow us to monitor the effect of irradiation on the performance of our device.

SINGLE-MOLECULE SENSING WITH A NANOPORE: INSPIRATIONS FROM NATURE

Liviu Movileanu
Syracuse University

A nanopore may act as an amazingly versatile single-molecule probe that can be employed to reveal several important features of nucleic acids and proteins. The underlying principle of nanopore probe techniques is simple: the application of a voltage bias across an electrically insulated membrane enables the measurement of a tiny picoamp-scale transmembrane current through a single hole of nanometer size, called a nanopore. Each molecule, translocating through the nanopore, produces a distinctive current blockade, the nature of which depends on its biophysical properties as well as the molecule-nanopore interaction. Such an approach proves to be quite powerful, because single small molecules and biopolymers are examined at very high spatial and temporal resolutions. I will discuss our recent work that provided a mechanistic understanding of the forces that drive protein translocation through a nanopore. These measurements facilitate the detection and exploration of the conformational fluctuations of single molecules and the energetic requirements for their transition from one state to another.

CURRENT MODULATION BY DNA TRANSLOCATION THROUGH A CARBON NANOELECTRODE-INSTRUMENTED NANOPORE

Patrick Spinney, Scott Collins, David Howitt, Rosemary Smith
University of Maine-Orono, University of California-Davis

Rapid and cost-effective DNA sequencing is a pivotal prerequisite for the genomics era. Many of the recent advances in forensics, medicine, agriculture, taxonomy, and drug discovery have paralleled critical advances in DNA sequencing technology. Recently, electrical modulation of a protein ion channel or a solid-state nanopore by the translocation of DNA has been proposed as a means of achieving high speed, low cost DNA sequencing. In this work, carbon nanoelectrodes have been integrated within a solid-state nanopore in order to achieve simultaneous tunneling and resistive pulse sensing of a single DNA molecule translocation event. The device nanofabrication and results of testing with lambda ds DNA and a short ssDNA probe are presented. The results provide promising experimental evidence for the application of this method to DNA sequencing.

HYBRID BIOLOGICAL-SOLID-STATE CIRCUITS BASED ON INTEGRATED, SOLID-SUPPORT LIPID BILAYERS

Jared Roseman, Siddharth Ramakrishnan, Kenneth Shepard
Columbia University

We describe progress toward the development of hybrid biological-solid-state circuits based on solid-supported lipid bilayers integrated on complementary metal-oxide-semiconductor (CMOS) integrated circuits. In a first application, we describe the design of an integrated circuit powered in an aqueous environment from adenosine triphosphate (ATP). Power densities as high as 0.07nW/mm^2 have been observed using platinum electrodes. Transmembrane proteins embedded into lipid bilayers represent one of the central functional constructs of living systems and are involved in energetics, sensing, transport, and most critical cell functions. In our work, we seek to develop the technology for integrating solid-supported bilayer lipid membrane (SBLM) with CMOS integrated circuits to create a whole new class of hybrid biotic-abiotic integrated systems based on the electrochemical coupling of these two technologies. Applications include both energetic (exploiting the lipid bilayer system to provide the power for the integrated circuit) and sensing (usingbiological transduction to membrane potentials).

ELECTRICALLY TUNABLE DNA TRANSLOCATION THROUGH A NANOPORE IN A MULTILAYERED SEMICONDUCTOR MEMBRANE

Maria Gracheva, Dmitriy Melnikov, Jean-Pierre Leburton
Clarkson University, University of Illinois at Urbana-Champaign

Numerical simulations can provide us with invaluable insight into the microscopic behavior of biomolecules as they translocate through artificial nanopores. With this in mind, we have developed a computational toolbox that allows us to examine how polymer dynamics will be affected by the electrostatic fields of semiconductor membranes submerged in electrolytic solution. To simulate the electrostatic potential and the charge carrier concentrations in the solid state membrane and the electrolyte, we have employed the electrostatic approach which is based on the selfconsistent solution of Poisson equation within the semiclassical approximation for charge carrier statistics in the membrane and electrolyte.

Poster Session

Tue Aug 30	Location: Main Hall
18:30-20:30	Chairs: John Zavada, NSF; Harold Grubin, University of Connecticut
	& Boris Gelmont, University of Virginia
1	GOOD OPTICAL LIMITING PERFORMANCE OF INDIUM AND GALLIUM PHTHALOCYANINES IN A SOLUTION AND SOLID PMMA COMPOSITE FILMS
	Ayhan Elmali, Ankara University-Turkey
2	POTENTIOMETRIC STRIPPING ANALYSIS OF METHYL PARATHION EMPLOYING CARBON NANOPARTICLES AND HALLOYSITE NANOCLAY MODIFIED CARBON PASTE ELECTRODE
	Ashwini Srivastava, University of Mumbai-India
3	THE LOCAL CHARGE CARRIER SCATTERING ON THE CRYSTAL LATTICE DEFECTS IN GAN
	Orest Malyk, Lviv Polytechnic National University-Ukraine
4	SILICON NANOCRYSTALS-EMBEDDED LANTHANUM FLUORIDE LAYER: A PROMISING INSULATING MATERIAL FOR ADVANCED MIS DEVICES
	Sheikh Al Ahmed, Rajshahi University-Bangladesh
5	AB-INITIO DENSITY-FUNCTIONAL THEORY CALCULATIONS ON THE EFFECTS OF APPLIED EXTERNAL VOLTAGE ON THE BANDGAP OF FLUORINATED GRAPHENE STRUCTURES
	Daniel Kaplan, U.S. Army RDECOM-ARDEC
6	FORMATION OF EPITAXIAL GRAPHENE ON SILICON CARBIDE: COMPARISON OF SI-FACE AND C-FACE
	Randall Feenstra, Carnegie Mellon University
7	SYNTHETIC CONTROL OVER THE STRUCTURE AND SYMMETRY OF CARBON NANOTUBES
	Michael Lowry, U.S. Naval Surface Warfare Center-Dahlgren Division
8	FABRICATION AND FRACTURE TOUGHNESS OF CRYOGENICALLY SOLIDIFIED ALUMINUM-ALLOY (LM-27) REINFORCED WITH NANO-ZRO2 METAL MAREIX COMPOSITE (CNMMCS)
	Joel Hemanth, Rajiv Gandhi Institute of Technology, India
9	QUANTUM CHEMICAL ANALYSIS OF THE EFFECT OF SILICON NANOCLUSTERS ON POINT MUTATIONS OF DNA
	Julia Gusakova, EPAM Systems-Belarus
10	METHOD FOR MEASURING THE ELECTRON TEMPERATURE IN MICROWAVE PHOTO-EXCITED TWO DIMENSIONAL ELECTRON SYSTEMS
	Aruna Ramanayaka, Georgia State University
11	MICROWAVE REFLECTION FROM THE MICROWAVE PHOTO-EXCITED TWO-DIMENSIONAL ELECTRON SYSTEM
	Ramesh Mani, Georgia State University
12	UNCOOLED NANOMETRIC SCALE BOLOMETER SYSTEM FOR THZ SENSOR ARRAY
	Aleksander Sesek, University of Ljubljana-Slovenia
13	EFFECTS OF PEPTIDE ADSORPTION ON THE ELECTRONIC PROPERTIES OF GRAPHENE
	Brahim Akdim, U.S. Air Force Research Laboratory
14	TAILORING OPTICAL RADIAITONS USING NANOPATTERNS
	Youngkyu Lee, University of Texas-Austin

Poster Session

Tue Aug 30	Location: Main Hall
15	VORTEX LINES IN TOPOLOGICAL INSULATOR - SUPERCONDUCTOR HETEROSTRUCTURES
	Matthew Gilbert, University of Illinois-Urbana
16	CHITIN NANOFIBER BIOPHOTONIC STRUCTURES VIA REPLICA MOLDING
	Marco Rolandi, University of Washington-Seattle
17	INTERFACING CELLS WITH PROTONIC TRANSISTORS FOR SENSOR APPLICATIONS
	Marco Rolandi, University of Washington-Seattle
18	ACOUSTO-OPTICAL PROPERTIES OF SILICON CRYSTALS IN VISIBLE RANGE OF SPECTRUM
	Farkhad Akhmedzhanov, Navoi Mining Institute-Uzbekistan
19	VALIDATION OF ELECTRICALLY MAGNETIC NANOPARTICLE CAPTURE AND CONCENTRATION OF E. COLI O157:H7 IN BROTH AND WHOLE FLUID MILK
	Barbara Cloutier, U.S. Army Research Office
20	DONOR-ACCEPTOR PYRENE ALKYLAMIDE DERIVATIVES AFFINITY FOR METALLIC CARBON NANOTUBES AND GRAPHENE
	Xiao-Qian Wang, Clark Atlanta University
21	POINT DEFECTS INTERACTION WITH IMPURITIES AT THE SI-SIO2 SYSTEM AND ITS INFLUENCE ON THE INTERFACE PROPERTIES.
	Daniel Kropman, Tallinn University of Technology-Estonia
22	CNT-ON-GRAPHENE COMPOSITE STRUCTURE AS TRANSPARENT-FLEXIBLE FIELD EMISSION DEVICE
	Indranil Lahiri, Florida International University
23	SCHRÖDINGER DYNAMICS AND ENERGY SPECTRUM OF AN ASYMMETRIC DOUBLE-QUANTUM-DOT SYSTEM IN A QUANTIZING MAGNETIC FIELD
	Peiji Zhao, NYU-Poly
24	1D STATIONARY-ELECTRODE MODEL OF TRAVELING WAVE ELECTROPHORESIS
	Robert Correll,
25	INSTABILITY IN CURRENT-VOLTAGE CHARACTERISTICS OF GATE-RECESSED ALGAN/GAN FIELD-EFFECT TRANSISTORS
	Wu Lu, Ohio State University
26	PIEZOELECTRIC TRANSDUCTION FROM MOLECULAR MODELS
	Jeremy Katusak, Texas A&M University
27	PEO AS THE HYDROPHILIC MATERIAL FOR CIRCULAR MICROCHANNEL FABRICATION IN PDMS USING SELF-ASSEMBLED INTERACTIONS
	Jeyantt Sankaran, University of Texas-Arlington
28	SERS DETECTION OF E. COLI USING THIN FILMS OF GOLD NANOPARTICLES
	Seong Seo, Albany State University
29	DIFFERENTIATION BETWEEN NORMAL AND CANCEROUS BREAST CELLS USING ATR-FTIR
	Seong Seo, Albany State University

Poster Session

Tue Aug 30	Location: Main Hall
30	MULTI-DIMENSIONAL SPARSE SURROGATE MODELS FOR DETERMINING LIGHT-INDUCED EFFECTS ON MOLECULAR CONFORMATIONS
	David Mokrauer, North Carolina State University
31	DESIGN, FABRICATION AND EVALUATION OF MICRO-SUPERCAPACITORS
	Chunlei Wang, Florida International University
32	SYNTHESIS OF AIR-STABLE, UNOXIDIZED BORON NANOPARTICLES USING BALL MILLING TECHNIQUE
	Jesus Perez, University of Utah
33	INVESTIGATION OF THERMAL DECOMPOSITION OF HMTD EXPLOSIVES
	Laurenee London, Clark Atlanta University
34	DROSOPHILA AS AN ECONOMICAL TEST PLATFORM FOR NANOMATERIAL ASSESSMENT
	Franklin Carrero-Martinez, University of Puerto Rico
35	DEVELOPMENT OF A SCALABLE BOTTOM-UP NANOFABRICATION PLATFORM FOR INTEGRATING MULTIFUNCTIONAL 3D NANOSTRUCTURES
	Peng Jiang, University of Florida
36	RAPID DETECTION AND MONITORING OF BACTERIAL PATHOGENS AND TRANSGENES USING MOLECULAR BEACON TECHNOLOGY
	Kellie Burris, University of Tennessee
37	PARALLEL IMPLEMENTATION OF THE WIGNER-POISSON FORMULATION FOR MODELING RESONANT TUNNELING DIODES
	Anne Costolanski, North Carolina State University
38	DNA PHOTONIC CRYSTAL FOR BIOCHEMICAL SENSING IN THE TERAHERTZ REGION
	Xiaoyang Huang, NYU-Poly
39	PATH LOSS CONSIDERATION OF A FAST BEAM SCANNING 2.2 THZ SPECTRAL IMAGING RADAR
	Tianying Chang, NYU-Poly
40	PREPARATION OF ORGANIC MOLECULES WITH PLANAR GEOMETRY FOR THE MODIFICATION OF CARBON NANOTUBES
	Laurenee London, Clark Atlanta University
41	A QUANTUM BOLTZMANN EQUATION FOR OPTICAL CONDUCTIVITY IN GRAPHENE
	Weidong Zhang, North Carolina State University

TECHNICAL SESSIONS – WEDNESDAY, August 31

Wednesday, August 31: 2011 NANO-DDS Conference: Room Assignment

Time Schedule	Pfizer Auditorium
Breakfast*	
08:00 – 08:25	Morning Plenary Talk: Dr. Alexandre Carella, Nanomaterials Technologies Department, CEA (France)
Morning Break**	

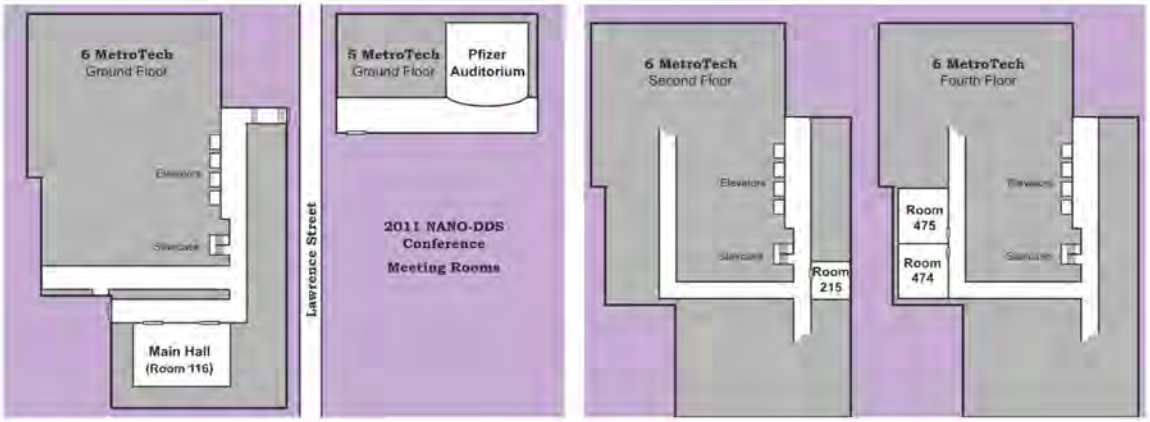
Time Schedule	Main Hall	Room 215	Room 474	Room 475
08:40 – 10:05	III(B1) Spectral-Detection Based Techniques	IV(C2) Low Power Systems	IV(A1) Engineered Nanoparticles - Properties	IV(S1) Graphene Growth & Functionalization
Morning Break**				
10:25 – 12:10	III(B1) Elec./Opt. Interaction Based Techniques	IV(C2) New System Functionality	III(A2) Nano-Electronics & Nano-Optics II	III(C1) Transduction-Based Bio-Sensing
Lunch Break**	★ Lunch Keynote Talk: Prof. Jadranka Travas-Sejdic, Department of Chemistry, University of Auckland (New Zealand)			
13:30	Free Afternoon			
13:45 – 17:30			Group Trip: American Museum of National History Meet in Main Hall, Ground Level of 6 Metrotech	
19:00 – 21:00	Conference Banquet Prospect Ballroom Sheraton Brooklyn New York Hotel 228 Duffield Street Brooklyn, New York			

* Breakfast will be served in front of the Pfizer Auditorium

** Morning/Afternoon Break food & drinks will be served in front of the Main Hall

★ The Lunch Keynote Talk will be given in the Main Hall.
Lunches will be provided (to all conference attendees) in the Main Hall.

2011 NANO-DDS Conference Meeting Site Map



Notes

Notes

Wednesday Aug. 31: Keynote & Plenary Talks

Wednesday Aug 31	Location: Pfizer Auditorium
8:00-8:25	CHEMICALLY FUNCTIONALIZED NANOMATERIALS BASED GAS SENSORS FOR THE DETECTION OF NERVE AGENTS
Plenary	Alexandre Carella, Cea-Liten, France 
12:15-12:45	Location: Main Hall
Lunch Keynote	LABEL-FREE DNA SENSORS BASED ON INTRINSICALLY CONDUCTING POLYMERS
	Jadranka Travas-Sejdic, University of Auckland-New Zealand 

CHEMICALLY FUNCTIONALIZED NANOMATERIALS BASED GAS SENSORS FOR THE DETECTION OF NERVE AGENTS

Alexandre Carella, Jean-Pierre Simonato
CEA-Liten Grenoble, France

Organophosphorus compounds represent one of the most important and lethal classes of chemical warfare agents (e.g. Sarin, Soman, Tabun). These agents have been used for terrorist attacks in the past (e.g. 1995 Japanese subway attack). Thus, the rapid sensing of OPs has recently become an increasingly important research goal. Nanomaterials based field effect transistors are extremely sensitive towards electrostatic change. Different strategies have been developed for the detection of organophosphorus compounds (OPs) using nanomaterials based field effect transistors functionalized with a chemical receptor specific to traces of organophosphorus agents. We demonstrated new concepts for electrical detection of OPs based on the chemical functionalization of a silicon nanowire field-effect transistor (SiNW-FET) or by the functionalization of the gold electrodes of a carbon nanotubes field effect transistor (CNTFET). The sensors are a very sensitive towards OPs.Moreover, a high selectivity necessary in the development of chemical sensors has been observed. We hope this technology of hybrid sensors compatible with CMOS technology will help to develop sensitive, compact, low-cost and low-consumption nomade devices for widespread applications in the fields of defense and homeland security.

LABEL-FREE DNA SENSORS BASED ON INTRINSICALLY CONDUCTING POLYMERS

Jadranka Travas-Sejdic, Hui Peng, David Williams, Bhuvaneswari Kannan, Cosmin Laslau, Marsilea Booth
University of Auckland-New Zealand, MacDiarmid Institute-New Zealand

A range of gene sensors based on derivatives of an intrinsically conducting polymer (ICP) polypyrrole and polythiophenes will be presented. These sensors are based on the electrochemical transduction of the hybridization event by the ICP thin films where the surface hybridization-induced changes in electrode kinetics of a redox couple was measured by electrochemical impedance spectroscopy and provide a simple, direct electrical and label-free gene sensing. Similar strategy has been currently extended onto ICP nanowires grown across microelectrode gaps in order to develop ultrasensitive biosensors. I will discuss issues around stability of ICP films for biosensing and show how the sensitivity of the detection of the complementary oligonucleotide (ODN) can be altered by morphology of the polymer layer. In addition, I will present how the electrochemical kinetics of ODN hybridisation can be used to estimate the equilibrium binding constant and binding kinetic rate constants for the hybridization reaction at the ICP surface. Applications of such sensors in detection of body fluids in forensically important samples will be briefly discussed.

III. Device Concepts & Sensor/System Functionality

Wednesday Aug 31	Location: Pfizer Auditorium
8:00-8:25	CHEMICALLY FUNCTIONALIZED NANOMATERIALS BASED GAS SENSORS FOR THE DETECTION OF NERVE AGENTS
Plenary	Alexandre Carella, Cea-Liten, France
	Location: Main Hall
Session III-B1	SPECTRAL-DETECTION BASED TECHNIQUES
	Chair: Dwight Woolard, U.S. Army Research Office (ARO)
8:40-9:05	EXPERIMENTAL DESIGN OF SINGLE-CRYSTAL DNA FOR THZ SPECTROSCOPY
Invited	Elliott Brown, Wright State University & Michael Norton, Marshall University
9:05-9:25	MICROWAVE AND UV-VIS FORENSIC PROBING OF SKELETAL TISSUE: MYOGLOBIN AS A MARKER
	Daniel van der Weide, University of Wisconsin-Madison
9:25-9:45	SUB-TERAHERTZ SPECTROSCOPY OF BIO-MATERIALS WITH HIGH SPECTRAL AND SPATIAL RESOLUTION
	Tatiana Globus, University of Virginia
9:45-10:10	NANOMATERIALS FOR FAST DETECTION OF DNA, PROTEIN AND CELLS
Invited	Claudio Parolo, Institut Català de Nanotecnologia, UAB, Spain
10:10-10:25	MORNING BREAK (in front of Main Hall)

III-B1. Spectral-Detection Based Techniques

EXPERIMENTAL DESIGN OF SINGLE-CRYSTAL DNA FOR THZ SPECTROSCOPY
E. R. Brown, M.L. Norton, M. Rahman, W. Zhang
Wright State University-Dayton, Marshall University-Huntington

We describe the first known spectroscopic investigation of crystalline DNA in the THz region. One immediate challenge is to grow large enough crystals for strong coupling to THz radiation. The “hanging-drop” method has yielded single crystallites up to ~100 mm in dimension, which have been loaded into sub-wavelength-scale metal pinholes and dielectric-hole arrays. However, the coupling to the DNA in such structures is rather weak and subject to strong scattering because of the random shape of the crystallites. Therefore, sub-wavelength coupling structures have been designed based on fundamental mode (TE11) circular waveguide and evanescent couplers located inside. The fabrication of such structures and experimental results will be reported at the conference.

MICROWAVE AND UV-VIS FORENSIC PROBING OF SKELETAL TISSUE: MYOGLOBIN AS A MARKER
Daniel van der Weide, Kimberley Taylor
University of Wisconsin-Madison

Identifying human remains is central to military and civilian forensics. Determination of both cause and time of death, particularly in cases of severe decomposition, is a significant challenge, but could be facilitated by quantitative analysis of skeletal muscle, which is only outlasted by bone itself. Myoglobin is abundant in skeletal muscle, and exhibits a strong UV-Vis absorption, and here we show a strong correlation between that absorption and unfolding/refolding peaks in solution measured with microwave reflectometry. This potential new tool for forensic identification of remains could be built as a portable sensor, facilitating use in the field. Preliminary results are discussed and improvements to future implementations suggested. Using microwave through terahertz frequencies to sense endogenous contrast in cells and sub-cellular structures such as proteins could enable quantitation of molecules without the use of fluorescent labels or visible-light spectrometers. This is of particular importance for biosensing in the field, where rugged and RF-compatible instrumentation would enable integration of several sensing platforms with existing radio infrastructure.

SUB-TERAHERTZ SPECTROSCOPY OF BIO-MATERIALS WITH HIGH SPECTRAL AND SPATIAL RESOLUTION

Tatiana Globus, Boris Gelmont, Aaron Moyer, Arthur Lichtenberger, Tatyana Khromova, Maryna Lvovska, Igor Sizov, Jerome Ferrance, Robert Weikle
University of Virginia, Vibratess LLC-VA

Terahertz (THz) vibrational spectroscopy is an emerging technique for characterization of biological and organic materials, but improving the sensitivity remains an important issue. Previous THz spectroscopic systems were impeded by ineffective coupling between light and the sample material, with the diffraction limit for spatial resolution another serious problem in THz imaging due to the much longer wavelengths compared with the visible and IR range. Here we show results on the development, implementation, and testing of a new optical, frequency-domain, resonant, and selective spectroscopic system operating at room temperature in the sub-THz spectral region. The developed prototype provides spectral resolution better than 0.035 cm^{-1}, detection sensitivity improved by more than an order of magnitude, and spatial resolution better than 200 microns, currently restricted by the opening of the microdetector waveguide. Highly resolved transmission (absorption) spectra from as low as 10-20 ng of biological macromolecules and bacterial cells/spores *Bacillus subtilis* (BG) and *E.coli* (E.c) are demonstrated. Experimental results are confirmed by comparison with molecular dynamic (MD) simulation for protein thioredoxin. This promises high discriminative capability not only between species, but between different strains, such as pathogens and non-pathogens of the same specie.

NANOMATERIALS FOR FAST DETECTION OF DNA, PROTEIN AND CELLS

Claudio Parolo, Alfredo de la Escosura Muniz, Marisa Maltez de Costa, Arben Merkoci
Institut Catala de Nanotecnologia-Spain, Universidad de Zaragoza-Spain

The need for fast, low cost and efficient in-field testing of biomolecules with interest for safety and security issues has increased enormously in the last few years. In this context biosensor technology represents an interesting alternative for the development of such devices that should in addition show user-friendly capacity. Between different biosensing alternatives the nanotechnology and nanomaterial oriented biosensors represent a very attractive tool for biosensing in general and that related to safety and security particularly. The design for such a purpose of nanomaterials based biosystems with special optical and electrochemical properties is bringing significant advantages. DNA, protein and even cell detections methodologies with interest for various applications and based on Nanomaterials (i.e. nonoparticles, nanochannels, nanotubes) will be described. The developed devices are based on the use of special platforms, which allows their future applications and extension in several fields. In addition these nanomaterial based biosensors are being offered as excellent screening alternatives to sophisticate and high cost equipments that require well prepared professionals for their use, including data treatment, prior obtaining of final results with interest for further decisions taken in analysis/screening scenarios.

IV. Materials, Fabrication and Integration for Sensor/System Architectures

Wednesday Aug 31	Location: Pfizer Auditorium
8:00-8:25	CHEMICALLY FUNCTIONALIZED NANOMATERIALS BASED GAS SENSORS FOR THE DETECTION OF NERVE AGENTS
Plenary	Alexandre Carella, Cea-Liten, France
	Location: Room 215
Session IV-C2	LOW POWER SYSTEMS
	Chair: Deming Chen, University of Illinois at Urbana-Champaign
8:40-9:05	MILLIVOLT NANOSCALE DEVICES AND CIRCUITS USING METAL-INSULATOR TRANSITION (MIT) MATERIALS
	Mircea Stan, University of Virginia
9:05-9:25	MULTI-STATE QUANTUM DOT CHANNEL (QDC) FIELD-EFFECT TRANSISTORS (FETS): A NEW PARADIGM IN CIRCUIT DESIGN
	Faquir Jain, University of Connecticut-Storrs
9:25-9:45	ENERGY DISSIPATION AND CONVERSION IN NANOSCALE DEVICES
	Eric Pop, University of Illinois, Urbana-Champaign
9:45-10:10	POSSIBILITY OF PIEZOELECTRIC-FERROMAGNET BILAYER BASED MICROWAVE RESONATORS AND OSCILLATORS
Invited	Sayeef Salahuddin, University of California-Berkeley
10:10-10:25	MORNING BREAK (in front of Main Hall)

IV-C2. Low Power Systems

MILLIVOLT NANOSCALE DEVICES AND CIRCUITS USING METAL-INSULATOR TRANSITION (MIT) MATERIALS
Mircea Stan, Jiwei Lu, Stuart Wolf
University of Virginia

The main focus of this work is to reduce by orders of magnitude the power/energy of nanoelectronics devices, circuits and systems by exploiting the very steep sub-threshold swings achievable with metal-insulator transition (MIT) materials (Mott insulators) such as VO2 to develop, optimize and fabricate devices and circuits that work with power supplies in the millivolt range.

MULTI-STATE QUANTUM DOT CHANNEL (QDC) FIELD-EFFECT TRANSISTORS (FETS):
A NEW PARADIGM IN CIRCUIT DESIGN
Faquir Jain, Supriya Karmakar, Robert Corce, Mukesh Gogna, Ernesto Suarez, John Chandy, Evan Heller
University of Connecticut-Storrs, RSoft Design Group-NY

FETs using carbon nanotubes (CNTs) and graphene, Si and SiGe nanowires, and InGaAs-on-Si [1] channels are being pursued as an alternative to Si CMOS technology. Single electron transistors (SETs) as well as laterally-coupled quantum dot devices with Coulomb blockade barriers have been reported by Shaji *et al.* and others. Generally, these FETs process one bit at a time in their transport channel. This paper describes electrical characteristics of Quantum Dot Channel (QDC) FETs, which are fabricated by site-specifically self-assembly of multiple SiOx-cladded Si dots (3-4 nm core cladded with 1nm barriers) forming an n-channel on p-Si between the source and drain regions. The device structure, transfer and output characteristics are presented. Unlike conventional FETs, QDC-FET structures exhibit step-like ID-VG characteristics and discretely bunched ID-VD characteristics. This behavior is analogous to that of single electron transistors (SETs), however, *using more than a few electrons* and *operating at room temperature,* which can be harnessed for multi-valued logic.

ENERGY DISSIPATION AND CONVERSION IN NANOSCALE DEVICES

Eric Pop, Myung-Ho Bae, Albert Liao, Feng Xiong, David Estrada
University of Illinois, Urbana-Champaign

Energy dissipation, conversion and flow are of great importance for the design of energy-efficient electronics and energy-conversion systems. This is also a rich domain for both fundamental discoveries as well as technological advances. This talk will describe several recent lessons learned from examining dissipation in carbon nanotubes and graphene, as model materials for 1- and 2-dimensional electronics. For example, thermoelectric effects observed in graphene devices could be used to partially remove the heat generated during operation. The talk will also introduce recent advances in creating energy-efficient memory storage based on phase-change materials. The results suggest much room for the optimization of electronics and energy conversion devices through the design of nanoscale materials, geometry and interfaces.

POSSIBILITY OF PIEZOELECTRIC-FERROMAGNET BILAYER BASED MICROWAVE RESONATORS AND OSCILLATORS

Debanjan Bhowmik, Sayeef Salahuddin
University of California-Berkeley

We discuss the possibility of using piezoelectric-ferromagnet bilayers for microwave resonators and oscillators to generate electromagnetic waves thereby providing low power alternative to the transmitter and the antenna. Through a simulation based approach we show that ferromagnetic resonance can be triggered in nanomagnets placed on a piezoelectric substrate through surface acoustic waves. We also compare the performance of our device with that of spin torque nano oscillator, which has also been considered previously for such applications. We show that our device is superior to the later in terms of input power consumption and output power delivered.

IV. Materials, Fabrication and Integration for Sensor/System Architectures

Wednesday Aug 31	Location: Pfizer Auditorium
8:00-8:25	CHEMICALLY FUNCTIONALIZED NANOMATERIALS BASED GAS SENSORS FOR THE DETECTION OF NERVE AGENTS
Plenary	Alexandre Carella, Cea-Liten, France
	Location: Room 474
Session IV-A1	ENGINEERED NANOPARTICLES- PROPERTIES
	Chair: Avinash Pandey, University of Allahabad, India
8:40-9:05	ENHANCEMENT OF MAGNETIC AND TRANSPORT PROPERTIES IN DOPED RARE-EARTH MANGANITES AT THE NANO-SCALE
Invited	Wiqar Shah, King Faisal University-Saudi Arabia
9:05-9:25	SIMPLE AND QUICK SYNTHESIS OF BRIGHTLY FLUORESCENT GRAPHENE AND SOME NOVEL PERSPECTIVES
	Vyom Parashar, University of Allahabad, India
9:25-9:45	PERFORMANCE OPTIMIZATION OF CARBON NANOTUBE-BASED FIELD EMISSION DEVICES THROUGH INTERFACE ENGINEERING
	Indranil Lahiri, Florida International University
9:45-10:05	EFFECTS OF PH ON THE FUNDAMENTAL INTERACTION BETWEEN SINGLE-STRAND DEOXYRIBONUCLEIC ACID OLIGOMERS AND GOLD NANO PARTICLES
	Mark Griep, Columbia University
10:05-10:25	MORNING BREAK (in front of Main Hall)

IV-A1. Engineered Nanoparticles- Properties

ENHANCEMENT OF MAGNETIC AND TRANSPORT PROPERTIES IN DOPED RARE-EARTH MANGANITES AT THE NANO-SCALE

Wiqar Shah
King Faisal University-Saudi Arabia

The magnetic and transport behavior of La1-*x*Ca*x*MnO3+(x=0.48, 0.50, 0.52 and 0.55 and =0.015) compositions close to charge ordering, was studied through resistivity DC magnetization and AC susceptibility measurements. With time and thermal cycling (*T*<300 K) there is an *irreversible* transformation of the low-temperature phase from a partially ferromagnetic and metallic to one that is less ferromagnetic and highly resistive. For instance, an increase of resistivity can be observed by thermal cycling, where no effect is obtained for lower Ca concentration. The time changes in the magnetization are logarithmic in general and activation energies are consistent with those expected for electron transfer between Mn ions. The data suggest that oxygen non-stoichiometry results in mechanical strains in this two-phase system, leading to the development of *irreversible* metastable states, which relax towards the more stable charge-ordered and antiferromagnetic microdomains. This behavior is interpreted in terms of strains induced charge localization at the interface between FM/AFM domains in the antiferromagnetic matrix. Charge, orbital ordering and phase separation play a prominent role in the appearance of such properties, since they can be modified in a spectacular manner by external factor, making the different physical properties metastable. Here we describe two factors that deeply modify those properties, viz. the doping concentration and the thermal cycling. The metastable state is recovered by the high temperature annealing. We also measure the magnetic relaxation in the metastable state and also the revival of the metastable state (in a relaxed sample) due to high temperature (800 C^{o}) thermal treatment.

SIMPLE AND QUICK SYNTHESIS OF BRIGHTLY FLUORESCENT GRAPHENE AND SOME NOVEL PERSPECTIVES

Vyom Parashar, Avinash C Pandey
University of Allahabad, India

Graphene with its incredible debut in 2004 marks an important breakthrough, as it has long been argued that free standing atomically thin materials cannot exist at ambient conditions because nature outlawed the formation of such structures. Artificial synthesis of 2D carbon allotropes is based on three principal routes. The first is, a micromechanical cleavage, second route is to grow a 2D monolayer embedded in 3D space as an inherent part of the system and then remove the third dimension at sufficiently low temperatures and third is to split strongly chemically loosened graphite into individual atomic plane. Furthermore, efforts to find alternative methods for producing carbon nanosheets starting from non graphitic precursors have been made. Most of the aforementioned methods are cumbersome in view of a large sum of time and energy participating, in addition to low yields and processing limitations. Regarding its potential applications in photonics, luminescence properties of graphene have attracted much recent attention. Here we demonstrate a "backyard" method of producing graphene from methanol and sodium hydroxide in an inert atmosphere employing easily available and inexpensive instruments. With this recipe what was once an expensive method may become less expensive. Moreover, the luminescence behavior of methanol derived graphene is also addressed. We have shown that methanol derived graphene brightly fluoresce when subject to infrared laser pulses at 976 nm and 1064 nm. The resulting brightly fluoresce graphene not only offers a simple recipe of synthesis but, more importantly, enable a new imaging probe for various applications.

PERFORMANCE OPTIMIZATION OF CARBON NANOTUBE-BASED FIELD EMISSION DEVICES THROUGH INTERFACE ENGINEERING

Indranil Lahiri, Wonbong Choi
Florida International University

Carbon nanotubes (CNT) have shown good potential for application as electron sources in electron microscopes, x-ray generators, field emission displays, microwave power amplifiers etc. CNT based cold field electron emitters have thus become popular. Our recent research efforts have shown that CNT field emitters perform differently when they have different substrate/underlayer/catalyst. Interface engineering seems to play an important role in determining response of these devices. A low-resistance interface between CNTs and substrate offers an easy path to electrons for achieving lower turn-on field and higher emission current density. Further, strong bonding between CNT-interface-substrate ensures stability of emission and improves device life-time. We have demonstrated how interface engineering controls emission response, have correlated emission behavior with interface properties and finally, proposed an optimized structure for enhanced emission.

EFFECTS OF PH ON THE FUNDAMENTAL INTERACTION BETWEEN SINGLE-STRAND DEOXYRIBONUCLEIC ACID OLIGOMERS AND GOLD NANO PARTICLES

Molly Karna, Mark Griep
U.S. Army Research Laboratory-APG, Columbia University

The size-tunable optical properties and biocompatibility of gold nanoparticles (GNPs) have attracted a great deal of attention in their applications as an effective, sensors, bio-labels, and imaging agents. However, a fundamental understanding of the nature of interactions between GNPs and DNA remains largely lacking. In order to develop such an understanding, we have performed experimental investigation, with the help of spectroscopic and atomic force microscopic (AFM) measurements, on GNP and single strand (*ss*) DNA oligomer hybrid systems. The Au nanoparticles were synthesized in house via the citrate reduction method. AFM images and UV-Visible spectroscopy of the mixture provided evidence for the binding of GNP with ss-DNA under mildly acidic conditions. The experiments suggest GNP agglomeration and association with the DNA strand in a rather random manner. Complimentary quantum chemical studies done by Bale et al. suggest charge transfer from the base molecule guanine to the gold atoms. However, the current experimental methodologies were unable to provide any discernable information about the nature of the binding between Au atoms and the DNA strand. A detailed analysis of the experimental data with additional spectroscopic measurements will be presented at the meeting.

IV. Materials, Fabrication and Integration for Sensor/System Architectures

Wednesday Aug 31	Location: Pfizer Auditorium
8:00-8:25	CHEMICALLY FUNCTIONALIZED NANOMATERIALS BASED GAS SENSORS FOR THE DETECTION OF NERVE AGENTS
Plenary	Alexandre Carella, Cea-Liten, France
	Location: Room 475
Session IV-S1	GRAPHENE GROWTH & FUNCTIONALIZATION
	Chair: Elias Towe, Carnegie Mellon University
8:40-9:05	EMPLOYING GRAPHENE MONO-AND MULTILAYERS IN NANOELECTRONIC BIOSENSORS
Invited	Amal Kasry, Egypt Nanotechnology Center, IBM T. J. Watson Research Center
9:05-9:25	BOTTOM-UP GROWTH OF MICRO- AND NANOPATTERNED GRAPHENE
	Nathaniel Safron, University of Wisconsin
9:25-9:45	GRAPHENE FILMS GROWN ON INSULATING SUBSTRATES
	Siarhei Samsonau, College of Staten Island, The City University of New York
9:45-10:05	APTAMER-BASED SMALL-ANALYTE DETECTOR ON A GRAPHITE ELECTRODEAPTAMER-BASED SMALL-ANALYTE DETECTOR ON A GRAPHITE ELECTRODE
	Michael Stroscio, University of Illinois-Chicago
10:05-10:25	MORNING BREAK (in front of Main Hall)

IV-S1. Graphene Growth & Functionalization

EMPLOYING GRAPHENE MONO-AND MULTILAYERS IN NANOELECTRONIC BIOSENSORS
Amal Kasry
Egypt Nanotechnology Center, IBM T. J. Watson Research Center

Graphene, a single layer of carbon atoms arranged in a hexagonal lattice, is one of the most stable 2D structures. Some of its extraordinary properties made it an ideal candidate for several applications in nanoelectronics and sensors. In this work graphene was grown by the CVD method. We began by studying the effect of stacking and doping on the resistance of graphene. The stacking and doping of graphene layers lead to a significant increase in the graphene conductivity to a value suitable for several electronic applications. Growth conditions of graphene were optimized to achieve smooth graphene layers that allowed for optical measurements to determine the optical parameters of graphene such as refractive index and extinction coefficient. This was done by using an orthogonal mix of techniques including ellipsometer, X-ray photoelectron spectroscopy (XPS), Raman Spectroscopy, Surface Plasmon Resonance (SPR) and Medium Energy Ion Scattering (MEIS). Measuring both the electrical and the optical properties of graphene allowed us to observe the ability of graphene to sense biomolecules and study biomolecular interactions. Graphene is a material that can not easily be chemically modified. In this work we studied graphene modification by electrostatic interaction using a molecule synthesized by IBM Research. Successful modification was proven by XPS, Raman Spectroscopy, Surface Plasmon Resonance and fluorescence spectroscopy. Studies of the chemical modification, along measurement of electrical and optical properties of graphene are components of our work to develop highly sensitive optical and electrical biosensors

based on carbon nanomaterials.

BOTTOM-UP GROWTH OF MICRO- AND NANOPATTERNED GRAPHENE
Nathaniel Safron, Myungwoong Kim, Padma Gopalan, Michael Arnold
University of Wisconsin-Madison

Graphene has received tremendous attention because of its exceptional properties such as its ultrafast charge transport characteristics; excellent mechanical strength, flexibility, and resilience; outstanding thermal conductivity; and its ultrahigh surface area to volume ratio. Groundbreaking frequency response and high current density, combined with its inherent compatibility with top-down planar processing methods, make graphene a promising candidate for future transistor logic applications. Additionally, its high transparency, flexibility and mobility make it a suitable semiconductor material for many thin-film transistor and sensing applications. For many applications, it is not continuous graphene that is desired but patterned graphene, i.e., for the purpose of defining devices architectures, altering its electronic properties through quantum confinement effects, enabling chemical functionalization of its edges, or fabricating pores for mechanical structures. Traditionally, patterning of graphene has been achieved via *top-down* chemical or physical etching, which induces defects, disorder, edge roughness, and unwanted chemical functionalization.

GRAPHENE FILMS GROWN ON INSULATING SUBSTRATES
Siarhei Samsonau, Yury Deshko, Anshel Gorokhovsky, Alexander Zaitsev
College of Staten Island, The City University of New York

We report a method of direct CVD growth of carbon films on single crystal quartz placed
in a high temperature graphite chamber filled with methane. The films grown this way reveal well developed G- and 2D-bands characteristics of polycrystalline graphene. Raman, AFM and optical absorption measurements allow us to conclude that the films are formed of single-layer polycrystalline graphene uniformly covering the whole surface of the substrate. Sheet resistance of these graphene films is low enough to make them interesting objects for electronic applications. Selective growth of the graphene films has been achieved on quartz substrates pretreated with oxygen and methane plasma. This finding may be used for development of a new lithographical method of direct fabrication of graphene-based electronic structures on insulating substrates. So far, we see no factors limiting the area of deposition and uniformity of graphene grown by the proposed method.

APTAMER-BASED SMALL-ANALYTE DETECTOR ON A GRAPHITE ELECTRODEAPTAMER-BASED SMALL-ANALYTE DETECTOR ON A GRAPHITE ELECTRODE
Michael Stroscio, Mitra Dutta, Jun Qian
University of Illinois-Chicago

As is well-known, aptamer are artificial short sequence DNA or RNA which act as receptors toward binding to targets of interest such as proteins, small molecules, DNA, cells, and even inorganic ion with high specificity. Aptamers have a number of advantages over their corresponding antibodies: (a) aptamers are more stable for long term storage without degradation, and (b) have been observed to sustain multiple usages without loss of sensitivity, while antibodies may suffer irreversible damage; (c) aptamers are more cost-effective to prepare through automatic synthesis in vitro; (d) easy to modified with further chemistry and engineering, such as immobilization functionalities or fluorophores; and (e) synthesis does not involve the use of animals. In this study, an aptamer-based sensor on a graphite platform is discussed. Specifically, in this study a graphite-based FET-like aptamer sensor is studied for the case of an aptamer that binds to a cocaine surrogate; the aptamer-based structure has a six-carbon amino at 5' end and seven-carbon MB(methylene-blue)-modified at 3'; i.e., NH_2-C6-5'-GAC AAG GAA AAT CCT TCA ATG AAG TGG GTC-3'-C7-MB. MB is an electron donor, while chemical oxidation-reduction synthesized graphene usually exhibits p-type semiconductor behavior with holes as carriers. 1-pyrenebutanoic acid, succinimidyl ester (P130) is used as linker molecule to noncovalently bind the aptamer to the graphene surface by the pyrene group as the protocol for CNT. When the target molecule, cocaine, is present, the aptamer undergoes a conformation change and results in a change in the distance between MB and the graphene surface, varying the electrical properties of the graphene-FET.

III. Device Concepts & Sensor/System Functionality

Wednesday Aug 31	Location: Main Hall
Session III-B1	ELECTRO/OPTICAL-INTERACTION BASED TECHNIQUES
	Chair: Alexander Sinitskii, University of Nebraska-Lincoln
10:25-10:50	ON-CHIP OPTICAL RESONATORS FOR SINGLE NANOPARTICLE DETECTION AND MEASUREMENT
Invited	Lan Yang, Washington University-St. Louis
10:50-11:10	DNA BASED NANOSTRUCTURES AS COMPONENTS OF A SANDWICH ASSAY FOR RICIN
	Michael Norton, Marshall University
11:10-11:30	A BIOCOMPATIBLE PROTONIC (H+) TRANSISTOR AS A NOVEL TOXIN SENSING PLATFORM
	Marco Rolandi, University of Washington-Seattle
11:30-11:50	NANOLASER ENABLED COHERENT BARCODING TECHNOLOGY
	Jian Xu, Penn State University
11:50-12:10	SELF-ASSEMBLED METAL NANOCLUSTER AND CARBON NANOTUBE MATERIALS WITH INCREASED CONDUCTIVITY
	Richard Claus, NanoSonic
12:15-13:10	LUNCH BREAK: Main Hall
Lunch Keynote	LABEL-FREE DNA SENSORS BASED ON INTRINSICALLY CONDUCTING POLYMERS
	Jadranka Travas-Sejdic, University of Auckland-New Zealand

III-B1. Electro/Optical-Interaction Based Techniques

ON-CHIP OPTICAL RESONATORS FOR SINGLE NANOPARTICLE DETECTION AND MEASUREMENT
Lan Yang, Jiangang Zhu, Lina He, Sahin Ozdemir, Woosung Kim, Daren Chen
Washington University-St.Louis, MO

There is a great need for a portable device that can detect and characterize individual pathogens and other nanoscale objects in a single-shot measurement. Such a device can find a broad spectrum of applications for human health, homeland security, environmental monitoring and medical diagnosis. We will present a self-referencing sensing technique using a high-quality Whispering-Gallery-Mode (WGM) resonator on a silicon wafer for detection and measurement of single nanoparticles down to 20 nm. The innovative measurement scheme is based on mode splitting, i.e. splitting of single resonant mode into two modes, a phenomenon triggered by nanoscale objects in mode volumes of an ultra-high quality WGM resonator. Since the two modes reside in the same resonator, they serve as a reference to each other to achieve a self-referencing sensing scheme, from which the properties of the nanoscale objects, such as size or refractive index, can be derived precisely. In the experiments, we have detected and measured nanoscale objects, such as polymeric and inorganic particles, viruses and metallic particles, which continuously arrive to the resonator one by one, using an ultra-high-quality WGM resonator. Our approach can also identify the components of homogenous mixtures of particles.

DNA BASED NANOSTRUCTURES AS COMPONENTS OF A SANDWICH ASSAY FOR RICIN

Michael L. Norton, Masudur Rahman, Hong Zhong, David Neff, David Danley
Marshall University

A prototype sandwich assay for Ricin60 (RCA), which employs DNA-Origami-based nanostructures is reported. The assay consists of an electroactive polymer capture system (polypyrrole) that immobilizes target proteins, in this case RCA and biotinylated RCA (bioRCA). Soybean agglutinin (SBA) and casein are used as controls. These immobilized proteins were then probed with a biotinylated ricin-specific antibody (bioanti RCA Ab). The presence of the antibody was transduced using a streptavidin functionalized origami nanostructure, which was rendered visible by interaction with Draq5, an A-T minor groove DNA binding, far-red emitting fluorophore. *Ricin is the third most toxic substance known*, after plutonium and botulinum toxin, according to the US Environmental Protection Agency and the Center for Defense Information. In this analytical study, a DNA Origami nanostructure was designed to perform the function of a pseudo-secondary antibody. Two of the DNA sequences, or staples, included in the nanostructure design were modified with biotin. When interacted with neutravidin, the nanostructures become capable of specific binding to other biotinylated species, including bioanti RCA Ab or bioRCA used in this study. A fluorescence signal proportional to the number of bound nanostructures was produced using a fluorophore, which specifically binds DNA at A-T minor groove locations and emits in the far-red.

A BIOCOMPATIBLE PROTONIC (H+) TRANSISTOR AS A NOVEL TOXIN SENSING PLATFORM

Marco Rolandi, Chao Zhong, Yingxin Deng, Adnan Kapetanovic
University of Washington-Seattle

In nature, protonic and ionic currents are the basis for all information processing. Artificial devices that can control and monitor these currents are an ideal means for interfacing with living systems. We were the first to demonstrate a polysaccharide based biocompatible protonic field effect transistor (pro-FET). This pro-FET has proton transparent PdHx contacts. In maleic-chitosan nanofibers, the flow of protonic current is turned on or off by an electrostatic potential applied to a gate electrode. Protons move along the hydrated maleic-chitosan hydrogen bond network with a mobility of $\approx 4.9 \times 10^{-3} cm^2 V^{-1} s^{-1}$. They follow the hop and turn Grotthus mechanism responsible for conduction of intramembrane proton channels. Here, we will introduce novel toxin sensor concepts based on these devices. Cell-based sensors that monitor environmental cell-response by directly measuring cell proton potential will be described. This new approach is in contrast to the traditional impedance method. The cell proton gradient is directly measured with the protonic transistor and increased sensitivity is expected. Biomimetic device concepts for sensing toxins (anthrax, phallolysin) that form intramembrane proton channels will also be discussed.

NANOLASER ENABLED COHERENT BARCODING TECHNOLOGY

Jian Xu, Andrew Wang
Penn State University, OceanNanotech LLC

A coherent optical coding technology has been developed recently. Stimulated emission of colloidal nanocrystal quantum dots in high-quality (Q) factor microresonators, such as microbeads, is used as the optical signatures to identify, detect, recognize, sense, or screen in security tagging, anti-counterfeiting, and sensing applications with high sensitivity, accuracy and throughput. We have recently observed simultaneous and independent lasing actions of multi-size colloidal nanocrystal quantum dots (QDs) of CdSe/ZnS core-shell structures that are embedded in the same spherical microresonanor cavities. Energy coupling between lasing QDs that are within close proximity is substantially suppressed, which is in sharp contrast to their fluorescence behavior that is dominated by resonant nonradiative energy transfer. A model was established to depict the competing processes of bi-exciton radiative recombination and Föster-type resonant nonradiative energy transfer between adjacent NQDs, which explains the observation of simultaneous and independent lasing actions of multi-size NQDs in the present work. Our discovery of Föster-coupling-free lasing of multi-size QDs has led to the development of coherent optical coding products that hold great potentials in the applications of high-security tagging, high-capacity-anti-counterfeiting and bio/chemical sensors with extremely high sensitivity, accuracy and throughput.

SELF-ASSEMBLED METAL NANOCLUSTER AND CARBON NANOTUBE MATERIALS WITH INCREASED CONDUCTIVITY

Kenith Meissner, Ravish Majithia, Michelle Homer, Jacob Dennis, Richard Claus
Texas A&M University, NanoSonic, Inc.

The objective of this work has been to increase the electrical conductivity while retaining the mass density of self-assembled nanocomposite materials based on noble metal nanoclusters and selected polymers by incorporating carbon nanotubes. Self-assembled metal nanocluster/polymer coatings and free-standing materials with moderately high electrical conductivities and relatively low mass densities have been reported for several years. Specifically, electrical conductivities on the order of 107 S/m and mass densities on the order of 1 gm/cm3 have been demonstrated in elastic materials with modulus as low as 1 MPa. While such conductivities are higher than those of conducting polymers, and such mass densities are a few percent to a few tens of percent that of metals such as copper, silver and aluminum, these materials cannot be used as direct electrical and geometrical replacements for metal due to their lower conductivity.

IV. Materials, Fabrication and Integration for Sensor/System Architectures

Wednesday Aug 31	Location: Room 215
Session IV-C2	NEW SYSTEM FUNCTIONALITY
	Chair: Eric Pop, University of Illinois
10:25-10:50	3D FPGAS WITH NANOTECHNOLOGY
Invited	Deming Chen, University of Illinois at Urbana-Champaign
10:50-11:10	ADAPTIVE READING, WRITING, AND ERASING IN A MEMRISTOR CROSSBAR MEMORY
	Idongesit Ebong, University of Michigan
11:10-11:30	DETECTING VAPOR TRACES OF EXPLOSIVES USING SELF ASSEMBLED MONO LAYER ON SURFACE-MODIFIED MEMS CAPACITOR AND CMOS ELECTRONICS
	Drago Strle, University of Ljubljana, Slovenia
11:30-11:50	GRAPHENE BILAYERS: FABRICATION, ELECTRON TRANSPORT, AND POTENTIAL APPLICATIONS
	Emanuel Tutuc, University of Texas-Austin
11:50-12:10	THE NEXT CLASS OF COMPUTERS: MILLIMETER-SCALE
	Mingoo Seok, Columbia University
12:15-13:10	LUNCH BREAK: Main Hall
	LABEL-FREE DNA SENSORS BASED ON INTRINSICALLY CONDUCTING POLYMERS
Lunch Keynote	Jadranka Travas-Sejdic, University of Auckland-New Zealand

IV-C2. New System Functionality

3D FPGAS WITH NANOTECHNOLOGY
Deming Chen
University of Illinois at Urbana-Champaign

In this talk, we focus on the design and evaluation of 3D reconfigurable architectures that use new nanoscale materials synergistically. The architectures are based on CMOS/Nano hybrid techniques that incorporate nanomaterials such as carbon nanotube bundles, nanowire crossbars, and NEM relays into CMOS fabrication process. We develop customized design tools to evaluate these 3D FPGAs. Preliminary results show strong promise of combining 3D with nanotechnology for future FPGA design.

DNA BASED NANOSTRUCTURES AS COMPONENTS OF A SANDWICH ASSAY FOR RICIN
ADAPTIVE READING, WRITING, AND ERASING IN A MEMRISTOR CROSSBAR MEMORY
Idongesit Ebong, Pinaki Mazumder
University of Michigan-Ann Arbor

This work presents an adaptive method of operating a memristor crossbar memory. The method utilizes two pulses to sample the memristor device of interest. The memristor memory is prone to errors due to non-uniform resistance across the crossbar structure and high defect rate compared to flash memory. By mitigating the drawbacks of using the memristor, fast, low power, denser memories can be built to aid the ever growing reliable storage appetite of various computing applications. The proposed method is shown to be low power and process resistant in simulations using memristor models and transistors in IBM 130 nm CMOS process. Multiple applications for Chua's memristor have been proposed, but the most promising with respect to product development is the digital memory utilizing memristors as storage elements. A new paradigm with respect to memory is necessary for the continued growth in density of nonvolatile memory for anticipated growth in petascale and exascale computing. The memristor's simple structure, small size, and non-volatility make it a viable candidate for next generation memory technology.

DETECTING VAPOR TRACES OF EXPLOSIVES USING SELF ASSEMBLED MONO LAYER ON SURFACE-MODIFIED MEMS CAPACITOR AND CMOS ELECTRONICS

Drago Strle, Bogdan **Š**tefane, Igor Mu**š**evi**č**
University of Ljubljana, Slovenia, Institute Jozef Stefan, Slovenia

Detecting vapor traces of explosives in the atmosphere is a potentially powerful method to reveal the presence of explosives and land mines. The principle of detection method is based on the fact that any explosive device will constantly emit rather small, but detectable number of different molecules, constituting the explosive. Common limitations of existing detection systems are rather large size, high power consumption, unreliable detection with false alarms, insufficient sensitivity and chemical selectivity, or hyper-sensitivity to mechanical influences and very high price. In this work, we describe a sensor measurement system, where extremely small capacitance changes caused by adsorption of explosive molecules on the functionalized surfaces are measured. MEMS sensor has fixed COMB fingers that are chemically modified using self-assembled mono layer. A dielectric constant of one capacitor is changed because of adsorbed molecules and this is what we are measuring using extremely sensitive electronic measurement system. It is possible to detect less than 3ppt of TNT in the atmosphere (3 TNT molecules in 10+12 molecules of N2) at 25oC in 1Hz bandwidth using only a few mm3 and approx 20mA current at 3.3V supply voltage. It is possible to improve the sensitivity down to 0.1ppt TNT in the air at 1Hz band.

GRAPHENE BILAYERS: FABRICATION, ELECTRON TRANSPORT, AND POTENTIAL APPLICATIONS

Emanuel Tutuc, Sanjay Banerjee, Seyoung Kim, Kayoung Lee, Babak Fallahazad, Chris Corbet
University of Texas-Austin

Graphene represents an interesting platform for electron physics and potential device applications. We describe here the fabrication, and electron transport in graphene bilayers. Two device structures are discussed: dual-gated graphene bilayers in Bernal stacking, and independently contacted graphene bilayers. Dual-gated graphene bilayer devices allow independent control of electron density and transverse electric field, and reveal a transverse electric field tunable band-gap, which in turn can improve the on/off ratio of graphene field-effect transistors. The second type of graphene bilayer consists of two independently contacted graphene mono-layers separated by an ultra-thin dielectric. We present the fabrication of such devices, the characterization of individual layers, and the role of inter-layer interaction. We discuss potential applications for such devices.

THE NEXT CLASS OF COMPUTERS: MILLIMETER-SCALE

Mingoo Seok
Columbia University

Millimeter-scale computers with years of lifetime can bring revolutionary advancements in numerous fields. In battlefields, these tiny computers can be deployed for surveillance without getting noticed. On the other hand, they can be implanted in human body to monitor physiological signs without having to be replaced. However, it is very challenging to create such computers. Why? Conventional circuit and system design techniques fail to deliver the sufficient energy efficiency to satisfy such long lifetime with the constraint of almost invisible system size. In this talk, I will discuss ultra low voltage systems and present a range of new circuit and architectural design approaches to substantially improve the energy efficiency, and thus make the vision of millimeter computing a reality. Finally, I will also speculate on possible ways that post-CMOS devices could play a significant role in this new class of computing.

III. Device Concepts & Sensor/System Functionality

Wednesday Aug 31	Location: Room 474
Session III-A2	NANO-ELECTRONICS & NANO-OPTICS II
	Chair: Peter Burke, University of California-Irvine
10:25-10:50	GRAPHENE-BASED NANO-ANTENNAS FOR ELECTROMAGNETIC COMMUNICATION AMONG NANO-DEVICES
Invited	Josep Jornet, Georgia Institute of Technology
10:50-11:10	FABRICATION OF VERTICALLY ALIGNED NANOWIRE ARRAYS WITH POROUS TOP ELECTRODES USING NANOSPHERE LITHOGRAPHY
	Pehr Pehrsson, U.S. Naval Research Laboratory
11:10-11:30	SUBWAVELENGTH MULTIMODE PLASMONIC TERAHERTZ LENSES
	Mustafa Karabiyik, Florida International University
11:30-11:50	CONCEPTUAL DESIGN IMPROVEMENTS FOR TERAHERTZ QUANTUM CASCADE LASERS NEEDED FOR MOLECULE DETECTION
	Tilmann Kubis, Purdue University
11:50-12:10	CONCEPT OF NONLINEAR-OPTICAL SENSOR FOR REMOTE MONITORING
	Alexander Popov, University of Wisconsin-Stevens Point
12:15-13:10	LUNCH BREAK: Main Hall
	LABEL-FREE DNA SENSORS BASED ON INTRINSICALLY CONDUCTING POLYMERS
Lunch Keynote	Jadranka Travas-Sejdic, University of Auckland-New Zealand

III-A2. Nano-Electronics & Nano-Optics II

GRAPHENE-BASED NANO-ANTENNAS FOR ELECTROMAGNETIC COMMUNICATION AMONG NANO-DEVICES
Josep Miquel Jornet, Ian F. Akyildiz
Georgia Institute of Technology

Nanotechnology is enabling the development of novel devices in a scale ranging from one to a few hundred nanometers, which are able to perform only very simple tasks, such as computing, data storing, sensing and actuation. By means of communication, nano-devices will be able to overcome their individual limitations and expand their potential applications in several fields. A wireless network of nano-devices will be able to cover larger areas, to reach unprecedented locations in a non-invasive way, and to perform additional in-network processing and coordinated actuations. Recent advancements in graphene-based electronics have opened the door to electromagnetic (EM) communications at the nanoscale. In this paper, a novel antenna design based on a metallic Graphene Nanoribbon (GNR), which resembles a nano-patch antenna, is investigated. For this, a quantum mechanical framework is first set to analyze the transmission line properties of metallic GNRs with multiple conducting energy bands. Then, the proposed antenna design is analyzed and evaluated. Numerical results show that, for a maximum antenna size in the order of several hundred nanometers (the expected maximum size for an integrated nano-device), a nano-patch antenna will be able to radiate EM waves in the Terahertz band (0.1-10.0 THz). While still not solving the communication problem at the nanoscale, these results motivate a further analysis of both, novel nano-antenna structures and propagation models suited for the nanoscale.

FABRICATION OF VERTICALLY ALIGNED NANOWIRE ARRAYS WITH POROUS TOP ELECTRODES USING NANOSPHERE LITHOGRAPHY

Pehr Pehrsson, Christopher Field, Hyun Jin In
U.S. Naval Research Laboratory-Washington,DC

Vertically aligned nanowire arrays can be highly effective in a wide array of applications including gas detection, electrochemical energy storage, and photovoltaic power generation. In such applications, the unique nanoscale properties of each nanowire are fully maximized in a massively parallel fashion. The vertically aligned configuration further enables ultra-dense placement of nanowires within the array while minimizing any adverse effects the substrate may have on the nanowires. In current state-of-the art devices that make use of vertical nanowire arrays, such as ultrasensitive gas sensors, bottom and top electrodes are required to electrically connect each nanowire in the array. While the substrate itself typically serves as the bottom electrode, the challenge lies in making a porous top electrode layer that electrically connects the tips of the nanowires while still allowing gases to pass through to the sensing areas beneath. Here, we present a quick, repeatable, and scalable new method based on the use of nanosphere lithography for creating large arrays of vertical nanowires with a periodically porous top electrode layer. We further apply this method in fabricating a highly sensitive gas sensor.

SUBWAVELENGTH MULTIMODE PLASMONIC TERAHERTZ LENSES

Mustafa Karabiyik, Chowdhury Al-Amin, Ahmad Abbas, Nezih Pala
Florida International University

We have designed a new subwavelength plasmonic lens for terahertz (THz) frequencies by utilizing 2 dimensional electron gas (2DEG) at AlGaN/GaN interface. The lens consists of concentric circular metallic gratings placed on the AlGaN layer. Plasmonic modes which are excited by incident THz radiation in the 2DEG under the metal gratings can be concentrated into $\lambda/350$- diameter area. The electric field intensity under the central point is orders of magnitude higher than the outer grating area. The plasmonic lens modes supported by the system can be tuned with an applied voltage to gratings.

CONCEPTUAL DESIGN IMPROVEMENTS FOR TERAHERTZ QUANTUM CASCADE LASERS NEEDED FOR MOLECULE DETECTION

Tillmann Kubis, Gerhard Klimeck
Purdue University

Security and gas sensing applications such as the nonintrusive detection of concealed weapons and the rapid detection of chemicals and explosives require a failsafe identification of complex molecules. Since many excitation lines of complex molecules lie in the terahertz (THz) regime of the light spectrum, these applications require coherent and intense THz light. Promising candidates for efficient and coherent THz light emission are THz quantum cascade lasers (THz-QCLs). So far, the operation of these lasers is limited to cryogenic temperatures. Recent theoretical and experimental work, however, have shown significant performance improvements. This suggests that operating THz-QCLs at temperatures beyond the limit of active cooling devices is feasible with a proper, still to be found THz-QCL design. Disadvantages in the design of state of the art THz-QCL are analyzed and alternative design concepts are combined within a concrete THz-QCL proposal. The design improvements are 1) suppression of electronic heating, 2) indirect pumping of the upper laser levels, 3) nonlocal optical transitions, 4) usage of materials with low effective electron masses and 5) a concrete growth orientation to protect the laser performance from growth variations. Nonequilibrium Green's function calculations of the stationary current and the optical gain of the proposed THz-QCL show a higher optical gain, an increased maximum laser operation temperature and a lower threshold current density compared to the conventional design.

CONCEPT OF NONLINEAR-OPTICAL SENSOR FOR REMOTE MONITORING

Alexander Popov
University of Wisconsin-Stevens Point

A concept of all-optically controlled, remotely actuated and interrogated, ultra-compact nonlinear-optical sensor, which can be employed for probing in remote or hostile locations, is proposed and the underlying theory is developed. Backwardness of electromagnetic waves propagating in the negative-index metamaterials plays a critically important role in the proposed concept. Difference-frequency, three- and four-wave mixing processes are investigated and numerically simulated, which utilize uncommon coherent energy transfer from the control optical field to the contra-propagating negative-phase wave. Such conversion leads to parametric amplification of the incident signal and to generation of frequency up-converted wave in the direction of reflection. Extraordinary features of the proposed microscopic devices applied to sensing applications are discussed. Numerical experiments have been carried out to identify optimum operational requirements and the anticipated properties of the proposed sensor.

III. Device Concepts & Sensor/System Functionality

Wednesday Aug 31	Location: Room 475
Session III-C1	TRANSDUCTION-BASED BIO-SENSING
	Chair: Michael Stroscio, University of Illinois-Chicago
10:25-10:50	IMPEDIMETRIC GENOSENSORS AND APTASENSORS BASED ON NANOMATERIALS
Invited	Manel del Valle, Universitat Autonoma de Barcelona, Spain
10:50-11:10	CONSTRUCTION OF HIGHLY CONDUCTIVE MOLECULAR WIRES FOR ELECTRONIC, SENSING, AND ENERGY CONVERTING DEVICES
	Nikolai Lebedev, U.S. Naval Research Laboratory
11:10-11:30	FABRICATION OF III-N RESONANT TUNNELING DEVICE STRUCTURES WITH DILUTE MAGNETIC BARRIER LAYERS
	Harold Grubin, NanoRTD
11:30-11:50	RAPID DETECTION OF AIRBORNE BIOLOGICAL PATHOGENS USING QUANTUM DOT FRET-BASED TECHNOLOGY
	Christopher Anton, Episensors, Inc.
11:50-12:15	FAST CARBON NANOTUBE SENSORS FOR GAS CHROMATOGRAPHY APPLICATIONS
Invited	Amin Salehi-Khojin, University of Illinois- Urbana/Champaign
12:15-13:10	LUNCH BREAK: Main Hall
	LABEL-FREE DNA SENSORS BASED ON INTRINSICALLY CONDUCTING POLYMERS
Lunch Keynote	Jadranka Travas-Sejdic, University of Auckland-New Zealand

III-C1. Transduction-Based Bio-Sensing

IMPEDIMETRIC GENOSENSORS AND APTASENSORS BASED ON NANOMATERIALS
Alessandra Bonanni, Merce Pacios, Maria Jose Esplandiu, Manel del Valle
Universitat Autonoma de Barcelona, Nanyang Technological University, Quantum Nanoelectronics Group CIN2 CSIC, Spain

DNA biosensors (genosensors) are rapidly developing as alternative to classical gene assays, thanks to advantages such as low cost, rapid analysis, simplicity and possibility of miniaturization. The determination of nucleic acid sequences from humans, animals, bacteria and viruses can be the departure point to solve different problems: investigation about food and water contamination caused by microorganisms, detection of genetic disorders or bioterrorism threats, tissue matching, forensic applications etc. Electrochemical Impedance Spectroscopy (EIS) is a characterization technique that provides electrical information in the frequency domain. Due to its ability for probing the interfacial properties at the electrode surface, EIS is lately being used for the very sensitive observation of bio-recognition events. We have used EIS as transduction technique for the development of genosensors, which have been applied in a number of cases, either in food analysis or in the early diagnose of genetically related disorders. In this case, the bio-recognition event is the Watson & Crick hybridization, opening way to the detection of specific gene sequences. As a second variant, we have also used EIS for protein recognition. In this case, specific oligonucleic acid sequences are used, which can bind to non nucleic acid target molecules like proteins, with high affinity and specificity. Such nucleic acid sequences are termed aptamers. They can be considered a substitute to antibodies for certain therapeutic and diagnostic applications. In the past decade, the use of nanoscale materials for electrochemical biosensing has seen an explosive growth. The ability to tailor the size and structure and hence the properties of nanomaterials offers excellent prospects for designing novel sensing systems and enhancing the performance of bio-analytical assays. As important recent trend in sensor development, it will be reviewed the use of nanoscale materials such as carbon nanotubes or interdigitated nano-gold, normally used to obtain novel sensing platforms using different linkage variants. Similarly, the use of Au nanoparticles will be described to label DNA sequences in order to achieve significant signal amplification in the procedures.

CONSTRUCTION OF HIGHLY CONDUCTIVE MOLECULAR WIRES FOR ELECTRONIC, SENSING, AND ENERGY CONVERTING DEVICES

Nikolai Lebedev, Scott Trammell, Stanislav Tsoi, Gary Kedziora, Igor Griva, Joel Schnur
U.S. Naval Research Laboratory-Washington, DC High Performance Technologies-WPAFB,
George Mason University

Electron transfer at organic-inorganic interfaces is a major roadblock in the construction of efficient chemical and biological sensing, soft optoelectronic, and energy converting devices. We have shown that the problem can be overcome by the construction of innovative molecules with the efficient electron delocalization and precise positioning of electron acceptor groups allowing for the efficient adjustment of the molecules and electrode Fermi levels, spatial charge distribution, and electron tunneling through space and solvent. Our experimental and simulation results demonstrate that the conductance through these molecules is highly efficient, coherent, and can achieve the theoretical limit of molecular conductance.

FABRICATION OF III-N RESONANT TUNNELING DEVICE STRUCTURES WITH DILUTE MAGNETIC BARRIER LAYERS

Brett Strawbridge, Nathan Newman, Harold Grubin
Arizona State University, NanoRTD, LLC.-CT

We have grown III-N resonant tunneling diodes for spin dependent magnetic field controlled high frequency operation, using a reactive molecular beam epitaxy process . The n-type GaN electrodes were intrinsically doped within _ 10 nanometers of the AlN barriers and then Si-doped to _ 1018=cm3 outside this region. We will illustrate the progress we have made using RHEED and EELS to monitor and control the growth process so that flat surfaces and sharp interfaces are routinely obtained. Preliminary measurements of the electrical properties demonstrate resonant tunneling behavior. The onset of diffuse negative differential resistance in this sample occurs at _ 1:25 volts. The current-voltage characteristics were found to be time dependent as a result of charge trapping at the interfaces. Work is underway to optimize the properties of structures with ferromagnetic Cr-doped AlN barriers in order to provide magnetic control of tunneling transport through the barrier. The design of the dilute magnetic barrier layer-RTD is based upon quantum statistical time-dependent numerical simulations and analysis of the spin-dependent Wigner equation. The results of the simulations will be briefly summarized.

RAPID DETECTION OF AIRBORNE BIOLOGICAL PATHOGENS USING QUANTUM DOT FRET-BASED TECHNOLOGY

Christopher Anton
Episensors,Inc.-IL

The development of a biological detection platform based on a novel quantum dot (QD) Fluorescent Resonant Energy Transfer (FRET) technology will be presented. A variety of surface functionalizations and conjugations are applied to the nanoscale QDs in order to create colloidal sensing elements. Monoclonal antibodies are used as receptors for biological pathogens of interest due to their high specificity and binding affinity to target pathogens. Quencher molecules are incorporated into the sensing elements in order to greatly reduce the optical output of the QDs under ultraviolet excitation. When pathogens of interest come into contact with the sensing elements, the quencher molecules are displaced and an increase in fluorescence is observed. This increase in optical signal is then converted to an electrical output using a photomultiplier. A variety of experimental results will be presented, ranging from bench-top studies demonstrating the capabilities of the QD FRET technology, to field tests of a fully integrated prototype sensor system capable of simultaneously collecting, detecting, and identifying multiple biological pathogens. Through these experiments, a rapid (2-5 minute assay time), sensitive (102 CFU's/ml), and versatile (multiplexed detection of up to 8 pathogens simultaneously) detection system has been demonstrated.

FAST CARBON NANOTUBE SENSORS FOR GAS CHROMATOGRAPHY APPLICATIONS

Amin Salehi-Khojin, Kevin Lin, Christopher Field, Fatemeh Khalili-Araghi, Marcelo Kurado, Jean-Pierre Leburton, Richard Masel
University of Illinois at Urbana-Champaign, Dioxide Materials-IL

The demand for sensitive sensors to detect harmful gas molecules is rapidly growing and carbon nanotubes (CNTs) have been increasingly used as the active element of these sensors. Carbon nanotubes offer very high carrier mobilities, fast response, better sensitivity, and wider variety of detectable analyte vapors compared to conventional materials. Two central problems of CNT sensors are selectivity and reversibility. These make it difficult for their application to gas chromatography (GC). In an effort to respond to such demanding need, this talk presents a newly discovered physics of nanotubes for selective, sensitive and reversible detection of analyte molecules. We have shown that defects play an important role in the behavior of carbon sensors. In particular, we have shown that defects can help to: (i) control the sensing mechanism of nanotube sensors, (ii) increase the sensitivity of the sensors at the onset of Poole-Frenkel conduction regime (electron hopping through defects), (iii) easily regenerate the sensors via current stimulated desorption (CSD), where high energy electrons stimulate the adsorbed gas molecules to desorb from the nanotube surface, and (iv) detect individual components of a gas mixture via an individual sensor. These advancements will be reviewed in this talk.

Notes

TECHNICAL SESSIONS – THURSDAY, September 1

Thursday, September 1: 2011 NANO-DDS Conference: Room Assignment

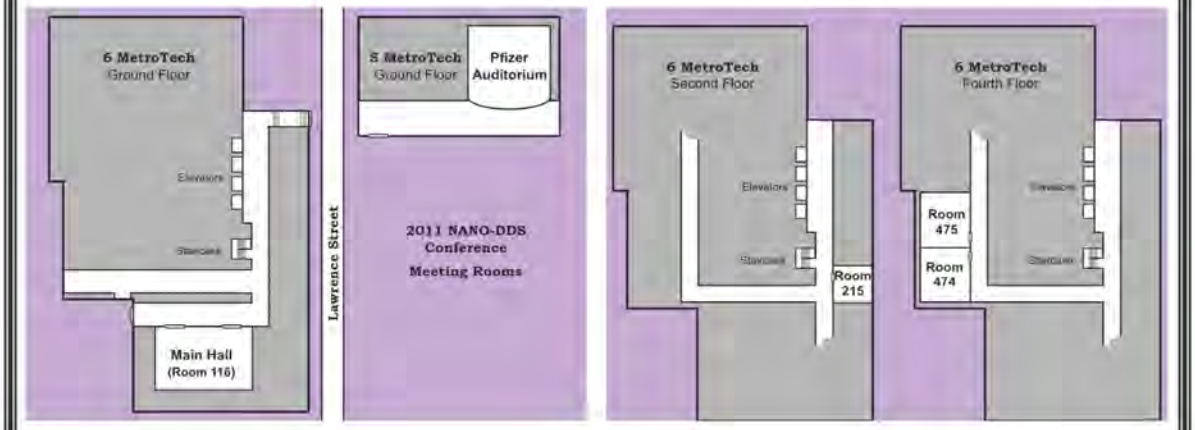
Time Schedule	Pfizer Auditorium
Breakfast*	
08:00 – 08:25	Morning Plenary Talk: Prof. Andrew Briggs, Department of Materials, University of Oxford
Morning Break**	

Time Schedule	Main Hall	Room 215	Room 474	Room 475
08:40 – 10:25	III(C2) Quantum-Driven Sensing	IV(C1) Nano-Architectures for Bio-Sensing	IV(A1) Engineered Nanoparticles for Bio-Sensing Devices	IV(S1) Graphene Analysis & Characterization
Morning Break**				
10:45 – 12:30	III(B1) Nano-Mechanical Based Techniques	III(A2) Bio-Nano Sensors	IV(A1) Engineered Nanoparticles for Gas Sensing Devices	IV(S1) Graphene Fabrication & Optimization
12:35	End of Conference			

* Breakfast will be served in front of the Pfizer Auditorium

** Morning Break food & drinks will be served in front of the Main Hall

2011 NANO-DDS Conference Meeting Site Map



Notes

Notes

Thursday Sept. 1: Plenary Talks

Thursday Sept 1	Location: Pfizer Auditorium
8:00-8:25	CARBON-BASED NANOELECTRONIC DEVICES
Plenary	Andrew Briggs, University of Oxford-UK 

CARBON-BASED NANOELECTRONIC DEVICES
Andrew Briggs
University of Oxford-UK

Quantum superposition and entanglement offer deep resources, which have yet to be harnessed in practical nanoelectronic devices. Superposition incorporates a phase with information content surpassing any classical mixture. Entanglement offers correlations stronger than any which would be possible classically. Together these give quantum computing its spectacular potential, but the implications extend far beyond information processing. Early applications may be found in sensing and metrology. Fundamental progress is being made in the development of carbon-based quantum devices incorporating electron and nuclear spins, which can be controlled with high precision.

III. Device Concepts & Sensor/System Functionality

Thursday Sept 1	Location: Pfizer Auditorium
8:00-8:25	CARBON-BASED NANOELECTRONIC DEVICES
Plenary	Andrew Briggs, University of Oxford-UK
	Location: Main Hall
Session III-C2	QUANTUM DRIVEN SENSING
	Chair: David Janes, Purdue University
8:40-9:05	THE ROLE OF CODON INTERACTIONS IN DEFINING THE OPTICAL SPECTRA DERIVED FROM ssDNA
	Peiji Zhao, North Carolina State University
9:05-9:25	SCALING LAW OF SILICON NANOWIRE BIOSENSORS
	Xuejin Wen, Ohio State University
9:25-9:45	PHOTOEXCITED TRANSPORT IN EPITAXIAL GRAPHENE
	Ramesh Mani, Georgia State University
9:45-10:05	INTERMOLECULAR CONDUCTANCE AND CHARGE TRAPPING IN PARAQUAT-TETRAPHENYLBORATE INVERSE PHOTOCHEMICAL CELL
	Nikolai Lebedev, U.S. Naval Research Laboratory
10:05-10:25	FUNCTIONALIZED COMPOUND ORGANIC MOLECULAR SWITCH DESIGN FOR NOVEL BIO-SENSING APPLICATION
	Greg Recine, NYU-Poly
10:25-10:45	MORNING BREAK (in front of Main hall)

IIIC-2. Quantum Driven Sensing

THE ROLE OF CODON INTERACTIONS IN DEFINING THE OPTICAL SPECTRA DERIVED FROM ssDNA
Peiji Zhao, Dwight Woolard
North Carolina State University, U.S. Army Research Office

The work to be reported will address these important scientific and engineering issues in the context of IR regime spectral sensing. The dependence between the DNA vibrational modes and base sequence in the DNA molecule will be interrogated in terms of ab initio based methods. Ultrafast and high throughput methods for the detection of the sequence of the bases in a DNA molecule are of importance to modern biology, medical research, and homeland defense. While biochemical methods are widely used in the laboratories in the world, label free techniques for the detection of the sequence of bases in a DNA molecule are also attracting the attention of the researchers. Optical methods have been widely used for the detection of the characteristics of materials because of the high sensitivity and accuracy of the methods. However, current optic or quasi-optic based label free techniques cannot provide the sequence information of the nucleotide bases in a DNA molecule. This is a long-standing unresolved and important scientific and engineering issue. One of the main hurdles to the resolution of the issue is the lack of the dependence between the vibrational modes and the sequence of the bases in a DNA wire.

SCALING LAW OF SILICON NANOWIRE BIOSENSORS
Xuejin Wen, Ayan Chakrabarty, Qi-Huo Wei, Wu Lu
Ohio State University, Kent State University,
Gwangju Institute of Science and Technology-Korea

Theoretical and numerical modeling of nanowire based electrical biosensors in the past focuses on equilibrium state. In this study, we investigate the Si nanowire biosensor sensitivity working in steady state conditions. The simulation results show that the smaller cross-sectional dimension and lower doping level improve sensitivity. At steady-state, the biomolecule

charges induce carrier concentration changes in both the active region and the source/drain regions. A longer nanowire exhibits higher sensitivity with enhanced effectiveness on modulating carrier concentration in the active region.

PHOTOEXCITED TRANSPORT IN EPITAXIAL GRAPHENE

Ramesh Mani, John Hankinson, Claire Berger, Walt de Heer
Georgia State University, Georgia Institute of Technology

We examine the low temperature electronic transport properties under microwave photoexcitation of multi-layer epitaxial graphene prepared by the thermal decomposition of SiC. Graphene refers to the one atom thick honeycomb lattice of carbon atoms that is rolled up into carbon nanotubes and stacked into layers in Graphite. Graphene constitutes a truly two-dimensional electronic system because the electronic wave function is confined to a single atomic layer, unlike in other planar (quasi) two-dimensional electronic systems. The linear dispersion relation in zero-gap semiconductors usually associated with relativistic particles provides for additional interesting electronic properties, such as the anomalous quantum Hall effect. It is also possible to open up a bandgap in graphene ribbons by size quantization. Finally, this material promises extraordinarily high mobility at room temperature, which can potentially be exploited for high speed device applications. Due to these and other interesting properties, Graphene is now viewed as a complementary material to Silicon for future electronics.

INTERMOLECULAR CONDUCTANCE AND CHARGE TRAPPING IN PARAQUAT-TETRAPHENYLBORATE INVERSE PHOTOCHEMICAL CELL

Nikolai Lebedev, Scott Trammell, Walter Dressick, Gary Kedziora, Igor Griva, Joel Schnur
U.S. Naval Research Laboratory-Washington, DC High Performance Technologies-WPAFB,
George Mason University

Miniaturization of electronic devices to the level of single molecules requires detailed understanding of the mechanisms of their operation. One of the questions here is the identification of the role of structural alterations in charge separation and stabilization in photoactive complexes. To address this question, we calculate optimized molecular and electronic structures, and optical and vibrational spectra of l,l'-dimethyl 4,4'- bipyridinium – bis tetraphenylborate $PQ(BPh_4)_2$ complex *ab initio* using density functional theory (DFT) approach and compare them with the experimentally observed UV-Vis and Raman spectra of the molecules in solid-state films. The results indicate that the association of PQ and BPh_4 leads to the formation of an internally ionized structure that is accompanied by the structural reorganization of both PQ (the twisting of pyridinium rings) and BPh_4 (phenyl rings rotation) moieties. The quanta of light do not seem to be directly involved in the formation of this ionized structure, but provide energy for fast recombination of the separated charges between BPh_4^- and PQ^{2+}. The high efficiency of the dark charge separation and the stabilization of separated charges in the complex permit the using of $PQ(BPh_4)_2$ in various charge-transfer devices like molecular probes, PV devices, or chemical memory units.

FUNCTIONALIZED COMPOUND ORGANIC MOLECULAR SWITCH DESIGN FOR NOVEL BIO-SENSING APPLICATION

Gregory Recine, Dwight Woolard, Weidong Zhang
NYU-Poly, U.S. Army Research Office, North Carolina State University

Semi-empirical molecular mechanics and *ab-initio* quantum mechanical studies of functionalized organic molecular switch (OMS) structures show that the basic OMS prototype can be extended to yield enhanced transport characteristic through the use of compound ring structures and/or chemically modified elements. This will allow for tuning of both the sensitivity and responsivity of this OMS paradigm. By applying semi-empirical molecular mechanics and *ab-initio* quantum mechanical techniques we can define an electronic functionality in organic molecules useful for sensing applications. Intrinsic to this discussion is the hypothesis, supported by simulation, that when a functional molecule is inserted into a periodic long molecular chain, the conformation dynamics of that molecule can change the molecular orbital (MO) energy structure, of the system, and in turn the electronic properties. The high density of MO's in such a system defines a type of "*pseudo-band structure*", that leads to a definable functionality of a type familiar to traditional electron devices. A typical prototype OMS design is where the functional molecule consists of a Benzoyl Chloride (Q) rings connected via a triple-bonded carbon pair to surrounding benzene (O) rings embedded into a long linear alkane (n-thiohenihectane). When a polar molecule is introduced close to the functional structure, the Q ring undergoes a rotation relative to the adjacent O-rings, which shifts the energy of that associated defect state. The goal of this particular design is to achieve electron conductivity that can be made very sensitive to exposure to external polar molecules.

IV. Materials, Fabrication and Integration for Sensor/System Architectures

Thursday Sept 1	Location: Pfizer Auditorium
8:00-8:25	CARBON-BASED NANOELECTRONIC DEVICES
Plenary	Andrew Briggs, University of Oxford-UK
	Location: Room 215
Session IV-C1	NANO-ARCHITECTURES FOR BIO-SENSING
	Chair: David Ricketts, Carnegie Mellon University
8:40-9:05	BRAIN BIOSENSING: FROM MICRO TO NANO
Invited	Anne Andrews, University of California-Los Angeles
9:05-9:25	ATTACHMENT OF AN ENGINEERED ANTIBODY TO A CARBON NANOTUBE TRANSISTOR FOR DETECTION OF PROSTATE CANCER BIOMARKERS
	Mitchell Lerner, University of Pennsylvania
9:25-9:45	OPTICAL AND ELECTRO-OPTICAL MODULATION OF BIOMIMETICALLY-FUNCTIONALIZED NANOTUBESCARBON NANOTUBES
	Padma Gopolan, University of Wisconsin-Madison
9:45-10:05	AMINO ACID INTERACTIONS WITH VARYING GEOMETRY GOLD NANOPARTICLES
	Mark Griep, U.S. Army Research Laboratory
10:05-10:30	BIONANOTECHNOLOGY-ENABLED MULTIFUNCTIONAL SENSING
Invited	Michael McAlpine, Princeton University
10:30-10:45	MORNING BREAK (in front of Main Hall)

IV-C1. Nano-Architectures for Bio-Sensing

ATTACHMENT OF AN ENGINEERED ANTIBODY TO A CARBON NANOTUBE TRANSISTOR FOR DETECTION OF PROSTATE CANCER BIOMARKERS

Mitchell Lerner, Jennifer Dailey, Tatiana Pazina, Matthew Robinson, A.T. Charlie Johnson
University of Pennsylvania, Fox Chase Cancer Center-Philadelphia, PA

We have developed a novel detection method for osteopontin (OPN), a new biomarker for prostate cancer, by attaching a genetically engineered single chain variable fragment (scFv) protein with high binding affinity for OPN to a carbon nanotube field-effect transistor (CNTFET). A chemical functionalization procedure involving diazonium salts is used to covalently attach the scFv to the carbon nanotube, as confirmed by atomic force microscopy, while preserving the activity of the biological binding site for OPN. Electronic transport measurements indicate that carbon nanotube transistors are able to detect the binding of OPN to its complementary scFv protein. A concentration-dependent increase in the source drain current is observed in the regime of clinical significance. Moreover, these devices exhibit selectivity for OPN over other control proteins since the scFv protein is designed specifically to bind OPN exclusively. Additionally, these devices are capable of moving away from purified samples and detecting OPN in a background of concentrated bovine serum albumin protein without any loss of signal. As a result of these device characteristics, the detection mechanism is attributed to charge transfer and local gate modulation around the carbon nanotube. The procedures developed herein are generalizable to any immunoglobulin containing an amine group for detection of its biologically complementary protein.

OPTICAL AND ELECTRO-OPTICAL MODULATION OF BIOMIMETICALLY-FUNCTIONALIZED NANOTUBESCARBON NANOTUBES

Padma Gopalan, Changshui Huang, Mark Eriksson, David McGee, Bryan Wong, François Léonard
University of Wisconsin-Madison, Sandia National Laboratories-Livermore, CA
Drew University-NJ

Light-triggered changes in biological molecules, which enable various functions such as vision, photosynthesis, and heliotropism, have long inspired materials chemists to mimic these phenomena to create new synthetic materials and devices. The molecule retinal undergoing a *cis-trans* isomerization in response to light, creating a cascade of events leading to visual recognition. Synthetic versions of retinal include switchable azo-benzene containing molecules. Recently, individual singlewalled carbon nanotubes (SWNTs) functionalized with azo-benzene chromophores were shown to form a new class of hybrid nanomaterials for optoelectronics applications. Here we use a number of experimental techniques and theory to understand the binding, orientation, and coupling between chromophores and the nanotubes. These techniques indicate that the binding energy between chromophores and nanotubes depends strongly on the type of tether that is used to bind the chromophores to the nanotubes. The chromophore-nanotube coupling, while weak, is sufficient to quench the chromophore fluorescence. The binding energy of the chromophores to the nanotubes is maximized for chromophores parallel to the nanotube sidewall, even with the use of tethers; second harmonic generation shows that there is nonetheless a partial radial orientation of the chromophores on the nanotubes. The chromophore orientation is an important variable for chromophore-nanotube phototransistors, and our experiments suggest the possibility for further optimizing this orientational degree of freedom.

AMINO ACID INTERACTIONS WITH VARYING GEOMETRY GOLD NANOPARTICLES

Hailey Cramer, Mark Griep, Shashi Karna
U.S. Army Research Laboratory-APG, University of Delaware

Developing the potential applications of gold nanoparticle (AuNP) and amino acid systems requires an understanding of their natural binding abilities. In this work the interactions between AuNPs and specified amino acids were studied to determine binding efficacy. AuNPs were synthesized through a citrate reduction method and experimental characterization was performed through the use of ultraviolet-visible spectroscopy (UV-Vis), fluorescence spectroscopy, energy dispersive x-ray spectroscopy, atomic force microscopy, and high resolution tunneling electron microscopy. The AuNPs were found to be of varying polycrystalline shapes with an average size of 8-9 nm. They absorbed at 220 nm and 521 nm, and emit at 314 nm and 630 nm. When the AuNPs were combined with a 1 mM solution of tryptophan in a 1:1 ratio, no obvious shift in energy levels were observed, suggesting no direct energy transfer interactions upon binding. Current work is focused on optimizing the molar ratio and pH to facilitate maximal AuNP/amino acid coupling. Fundamental understanding of the binding event will be explored to elucidate interactions between NPs and biomolecules and allow for the use of AuNP-amino acid hybrids in biomedical and biotechnology applications. A detailed analysis of the experimental data and ongoing research will be presented at the meeting.

BIONANOTECHNOLOGY-ENABLED MULTIFUNCTIONAL SENSING

Michael McAlpine
Princeton University

Molecular biomimetics is an emerging field in which the tools of molecular biology and nanotechnology are synergized. Of vital relevance is chemical and biological sensing. Biomimicking smart materials, which integrate chemical recognition elements with sensitive transducers could provide a general platform for highly specific analyte sensors. Graphene is a delicate single layer, two-dimensional network of carbon atoms whose properties can be affected by covalent modification. One method for functionalizing materials without fundamentally changing their inherent structure is using biorecognition moieties. In particular, oligopeptides are molecules containing a broad chemical diversity that can be achieved within a relatively compact size. Phage display is a dominant method for identifying peptides that possess enhanced selectivity toward a particular target. Here, we demonstrate a powerful yet benign approach for chemical functionalization of graphene via comprehensively screened phage displayed peptides. Our results show that graphene can be selectively recognized even in nanometer-defined strips. Further, modification of graphene with bifunctional peptides reveals both the ability to impart selective recognition of gold nanoparticles and the development of an ultrasensitive graphene-based TNT sensor. We anticipate that these results could open exciting opportunities in the use of graphene in fundamental biochemical recognition studies, as well as applications ranging from sensors to energy storage devices.

IV. Materials, Fabrication and Integration for Sensor/System Architectures

Thursday Sept 1	Location: Pfizer Auditorium
8:00-8:25	CARBON-BASED NANOELECTRONIC DEVICES
Plenary	Andrew Briggs, University of Oxford-UK
	Location: Room 474
Session IV-A1	ENGINEERED NANOPARTICLES FOR BIO-SENSING DEVICES
	Chair: Ravi Pandey, Michigan Technological University
8:40-9:05	ELECTROCHEMICAL DETECTION OF BRUCELLA ABORTUS CE-PROTEIN ANTIGEN AMPERO-METRICALLY BY USING NANO POROUS ZNO-NANOSHEET/CHITOSAN COMPOSITE SCREEN PRINTED ELECTRODES
Invited	V. K. Rao, Defense Research Development Establishment-India
9:05-9:25	CHARACTERIZATION OF MAGNETIC NANOPARTICLES FOR BIO-SENSING APPLICATIONS
	Han Song, Oregon State University
9:25-9:45	POTENTIOMETRIC STRIPPING ANALYSIS OF METHYL PARATHION EMPLOYING CARBON NANOPARTICLES AND HALLOYSITE NANOCLAY MODIFIED CARBON PASTE ELECTRODE
	Ashwini Srivastava, University of Mumbai-India
9:45-10:05	MULTIFUNCTIONAL CORE-SHELL NANOPARTICLES ALLOW FOR DISCOVERY OF PREVIOUSLY INVISIBLE PROTEIN BIOMARKERS
	Alessandra Luchini, George Mason University
10:05-10:25	QUANTUM CHEMICAL STUDY OF THE FUNDAMENTAL INTERACTIONS BETWEEN DEOXYRIBONUCLEIC ACID (DNA) OLIGOMERS AND Au NANO PARTICLES
	Radhakrishnan Balu, U.S. Army Research Laboratoty
10:25-10:45	MORNING BREAK (in front of Main Hall)

IV-A1. Engineered Nanoparticles for Bio-Sensing Devices

ELECTROCHEMICAL DETECTION OF BRUCELLA ABORTUS CE-PROTEIN ANTIGEN AMPEROMETRICALLY BY USING NANO POROUS ZNO-NANOSHEET/CHITOSAN COMPOSITE SCREEN PRINTED ELECTRODES

Vepa Kameswara Rao, Ajay Kumar Gupta, D. T. Selvam, Ashu Kumar
Defense Research Development Establishment-India

Brucella is the cause of brucellosis. Persons in contact with animals in dairy forms get this disease. Attempts were made for detection of Brucella abortus CE-antigen in human beings by utilizing amperometric immunosensors. The screen printed electrodes (SPEs) were modified by depositing porous ZnO-nanosheet/Chitosan composites on the electro-active surface area of SPEs. ZnO nanosheet was made by chemical bath deposition method. The SEM showed that the ZnO-nanosheet has porous nature inwhich the antibodies may get trapped. These modified electrodes were characterized by using cyclic voltammetry. These experiments proved that it has fast electron transfer rate. Also the electrochemical characteristics of the modified electrodes were studied with 1-naphthol. The amperometricresponse of these electrodes is superior to unmodified SPE. The sandwich enzyme linked immunosorbent assay system was used to detect CE protein antigen. An antibody conjugated to alkaline phosphatase is used as revealing antibody. The experimental conditions for immobilisation of antibodies on the electrode were optimized. It was found that the response of amperometric sensor is proportional to the CE-protein antigen concentration and is linear in the range of 6.25–100 μg/mL. At high concentrations the amperometric current was found to be less than the response at lower concentrations. This is similar to the prozone effect observed noramally in brucella detection. The detection limit was found to be 0.5ng/mL. While by conventional plate ELISA it is

possible to detect 50µg/mL only. The tests were performed on few clinical samples and the results were compared with conventional techniques.

CHARACTERIZATION OF MAGNETIC NANOPARTICLES FOR BIO-SENSING APPLICATIONS

Han Song, Sam Mulley, Nathan Coussens, Pallavi Dhagat, Albrecht Jander, Alexandre Yokochi
Oregon State University

NiFe2O4 and magnetite nanoparticles were characterized by ferromagnetic resonance (FMR) measurement. Ferromagnetic resonance field were analyzed to determine the internal magnetic field in these samples. The effects of sample orientation and particle density on the FMR measurements are investigated. The technique allows for small samples (~ 1 mg) to be measured, and provides rapid feedback in developing and optimizing synthesis methods for magnetic nanoparticles. Magnetic nanoparticles have a wide range of sensor applications, such as environment monitoring, bio-surveillance and medical diagnosis. To better understand the suitability of a particular material in the above uses, information on the magnetic properties of the nanoparticles is important. Ferromagnetic resonance (FMR) measurement is a powerful tool for analyzing and characterizing magnetic materials. FMR study on magnetic nanoparticles can reveal the effect of anisotropy and magnetic dipole interactions inside and between particles in the sample. In this work, FMR measurements have been done on NiFe2O4 and magnetite nanoparticles. The ability to rapidly and efficiently characterize magnetic properties with this technique, using only small sample quantities, enables optimization of synthesis processes for advanced magnetic nanoparticles.

POTENTIOMETRIC STRIPPING ANALYSIS OF METHYL PARATHION EMPLOYING CARBON NANOPARTICLES AND HALLOYSITE NANOCLAY MODIFIED CARBON PASTE ELECTRODE

Ashwini Srivastava, Bankim Sanghavi, Shashi Karna
University of Mumbai, India, U.S. Army Research Laboratory

A carbon nanoparticles and halloysite nanoclay modified carbon paste electrode (CNP- HNC-PE) was developed for the determination of methyl parathion (MP). The electrochemical behavior of this molecule was investigated employing cyclic voltammetry (CV), chronocoulometry (CC), electrochemical impedance spectroscopy (EIS) and potentiometric stripping analysis (PSA). These studies revealed that the reduction of MP is facilitated at CNP-HNC-PE. After optimization of analytical conditions employing this electrode at pH 5.0 in acetate buffer (0.1M), the peak current for MP was found to vary linearly with its concentration in the range of 2.55.

MULTIFUNCTIONAL CORE-SHELL NANOPARTICLES ALLOW FOR DISCOVERY OF PREVIOUSLY INVISIBLE PROTEIN BIOMARKERS

Alessandra Luchini, Davide Tamburro, Claudia Fredolini, Virginia Espina, Temple Douglas, Adarsh Ranganathan, Weidong Zhou, Paul Russo, Benjamin Espina, Emanuel Petricoin, Lance Liotta
George Mason University, Istituto Superiore di Sanità-Italy, S. Giovanni Bosco Hospital-Italy

Buoyant core-shell hydrogel nanoparticles containing combinations of novel reactive chemical baits were created. N-isopropylacrylamide-co-acrylic acid nanoparticles were functionalized with amino containing dyes via zero length crosslinking amidation reactions. A shell chemistry actively excluded unwanted abundant peptides of all sizes and baits immobilized in the core captured general classes of peptides with high affinity. Used in blood, urine and other body fluids as a one step, in-solution preprocessing step, the nanoparticles achieved 100 fold amplification of biomarker detection enabling the discovery of biomarkers that were previously invisible. Core shell hydrogel nanoparticles are highly relevant to national defense and security applications as enrichment technology that empowers present detection technologies.

QUANTUM CHEMICAL STUDY OF THE FUNDAMENTAL INTERACTIONS BETWEEN DEOXYRIBONUCLEIC ACID (DNA) OLIGOMERS AND Au NANO PARTICLES

Radhakrishnan Balu, Shashi P. Karna, Ravindra Pandey
U.S. Army Research Laboratory, Michigan Technological University

Theoretical investigation of mixture of gold nano particles (GNP) and single stranded DNA (ss-DNA) were carried out to characterize the nature of their interaction. The calculations suggest a possible charge transfer pathway from the DNA base guanine to Au atoms, thus characterizing the interaction as electrostatic. We also suggest possible effect of the presence of other bases to guanine mediated charge transfer. The presence of an adenosine base is found to alter the charge localization at the guanine base and prevents charge transfer to nanoparticles (NPs).

IV. Materials, Fabrication and Integration for Sensor/System Architectures

Thursday Sept 1	Location: Pfizer Auditorium
8:00-8:25	CARBON-BASED NANOELECTRONIC DEVICES
Plenary	Andrew Briggs, University of Oxford-UK
	Location: Room 475
Session IV-S1	GRAPHENE ANALYSIS & CHARACTERIZATION
	Chair: Shashi Karna, U.S. Army Research Laboratory
8:40-9:05	SCANNING TUNNELING SPECTROSCOPY OF GRAPHENE ON SILICON OXIDE AND BORON NITRIDE
Invited	Brian LeRoy, University of Arizona
9:05-9:25	SHEET RESISTANCE OF MULTI-LAYER GRAPHENE IN RADIO FREQUENCY
	Peter Burke, University of California-Irvine
9:25-9:45	OPTICAL PROPERTIES OF GRAPHENE ON SIC POLYMORPHS DETERMINED BY SPECTROSCOPIC ELLIPSOMETRY
	Tino Hofmann, University of Nebraska-Lincoln
9:45-10:05	FREQUENCY-DEPENDENT ELECTRON TRANSPORT IN GRAPHENE
	Nishant Sule, University of Wisconsin-Madison
10:05-10:30	FORMATION OF EPITAXIAL GRAPHENE ON SILICON CARBIDE: COMPARISON OF Si-FACE and C-FACE
Invited	Randall Feenstra, Carnegie Mellon University
10:30-10:45	MORNING BREAK (in front of Main Hall)

IV-S1. Graphene Analysis & Characterization

SCANNING TUNNELING SPECTROSCOPY OF GRAPHENE ON SILICON OXIDE AND BORON NITRIDE
Brian LeRoy, Jiamin Xue, Aparna Deshpande, Daniel Cormode, Philippe Jacquod, Javier Sanchez-Yamagishi, Danny Bulmash, Pablo Jarillo-Herrero, Kenji Watanabe, Takashi Taniguchi, Wenzhong Bao, Zeng Zhao, Jeanie Lau
University of Arizona, MIT, National Institute for Material Science-Japan,
University of California-Riverside

Graphene has shown tremendous promise for use in future electronics applications. However, the substrate that it rests on can greatly affect its electronic properties. On silicon oxide, at low charge density the graphene electrically breaks up into a series of electron and hole puddles. Using a small nanoparticle on the apex of an STM tip, we have mapped these electron and hole puddles with high spatial and energy sensitivity. Furthermore, when the graphene lies on silicon oxide it conforms to the surface leading a surface roughness which can cause scattering for electrons. When graphene is placed on hexagonal boron nitride both the surface roughness and puddles are greatly reduced. This leads to improved electrical performance of graphene devices fabricated on boron nitride. We have measured the topographic and local electronic properties of graphene on boron nitride using scanning tunneling microscopy. Using scanning tunneling microscopy, we have imaged local charge density fluctuations in monolayer graphene. By placing a small gold nanoparticle on the end of the STM tip, a charge sensor is created. The nanoparticle is small enough that only a discrete number of electrons can be added to it and it is in the Coulomb blockade regime. Therefore, small changes in its electrostatic environment cause the number of electrons on the nanoparticle to change. By raster scanning the tip over the surface and using Coulomb blockade spectroscopy, we can map the local potential on the graphene. We observe a series of electron and hole doped puddles with a characteristic length scale of about 20 nm.

SHEET RESISTANCE OF MULTI-LAYER GRAPHENE IN RADIO FREQUENCY
Nima Rouhi, Dheeraj Jain, Santiago Capdevila, Lluis Jofre, Elliott Brown, Peter Burke
University of California-Irvine, Universitat Politècnica de Catalunya-Spain, Physical Domains,LLC-CA

Broadband sheet conductance of few-layer graphene on single-crystal quartz substrate was studied. High frequency measurements at X-band (8-12 GHz), using WR90 waveguide and sheet resistance at W-band (75-100 GHz) and 1 THz range were performed which provides the basis for a comprehensive frequency sheet conductance calculation. Sheet resistance is extracted form the transmission coefficient (S_{21}). The results present small variation at different frequency bands, and are quite stable within the bands. Graphene a semi-metallic 2D material shows a great performance in DC and sensor applications. In addition, graphene exhibits a favourable optical response due to interband and intraband transitions. However, the performance of graphene-based devices in RF and Terahertz regime has rarely been explored in detail. Traditionally there have been two methods generally used for characterization of thin conductors (thin film). Resonant methods which rely on the measurement of the shift in frequency and the variation of the quality factor, and transmission methods, which perform the characterization through the variations in the transmission coefficient, S_{21}. This paper presents results in the calculation ofgraphene sheet conductance through transmission measurements.

OPTICAL PROPERTIES OF GRAPHENE ON SIC POLYMORPHS DETERMINED BY SPECTROSCOPIC ELLIPSOMETRY
Alexander Boosalis, Tino Hofmann, Stefan Schöche, Peter Dowben, Sneha Gaddam, C. Vamala, J. Kelber, R. Yakimova, V. Darakchieva, L. Nyakiti, V. Wheeler, R. Myers-Ward, C. Eddy, D.K. Gaskill, Mathias Schubert
University of Nebraska-Lincoln, University of North Texas-Denton, Linkoping University-Sweden, U.S. Naval Research Laboratory

We report on the optical properties of graphene determined over an extremely wide spectral range from terahertz (0.65 THz, 0.28 meV) to the VUV (9.5 eV) using spectroscopic ellipsometry. The graphene samples were deposited on a number of different substrates using multiple growth techniques. The terahertz and infrared ellipsometry and THz-IR optical Hall-effect investigations provide detailed information on the free-charge carrier properties of graphene. The analysis reveals multiple carrier channels with strongly varying mobility, effective mass, and density parameters and their dependence on the substrate. The ellipsometric data obtained in the visible and VUV spectral range show distinct differences in the complex dielectric function of graphene as the underlying substrate differs in material composition and polytype.

FREQUENCY-DEPENDENT ELECTRON TRANSPORT IN GRAPHENE
Nishant Sule, Irena Knezevic
University of Wisconsin-Madison

We present a frequency-resolved simulation of electron transport in graphene excited by electro-magnetic radiation using a coupled ensemble Monte-Carlo/Finite-difference time-domain (EMC/FDTD) technique. The electron-phonon scattering rates used in the EMC are calculated using electronic Bloch wave functions obtained within the tight-binding approximation. Including the overlap integral of these tight-binding Bloch wave functions reduces the scattering rates by several orders of magnitude with respect to using plane waves. The current calculated from EMC is used as input for the FDTD solver to calculate fields that in turn are used to accelerate electrons in EMC. We compare the complex conductivity of graphene resulting from this simulation with the Drude model.

FORMATION OF EPITAXIAL GRAPHENE ON SILICON CARBIDE: COMPARISON OF Si-FACE and C-FACE
Randall Feenstra, Guowei He, Nishtha Srivastava, Luxmi
Carnegie Mellon University

Graphene (one or a few monolayers of carbon in a hexagonal arrangement) has been formed on the Si-face and the C-face of silicon carbide, by heating the SiC to temperatures in the range 1200 – 1600 C in vacuum or in controlled atmospheres such as argon, neon, or disilane. Preferential sublimation of the Si from the surface leaves behind C, which self-assembles into graphene. The morphology of the surface has been studied by atomic force microscopy, and the morphology of the graphene layer(s) themselves have been studied by low-energy electron microscopy. Uniform, single monolayer graphene is relatively easy to form on the Si-face but much more problematic on the C-face, due to higher reactivity of the latter surface (i.e. to background contaminants such as oxygen). A study has been made of the formation of epitaxial graphene on SiC by heating SiC in vacuum or in various environments. In this process, silicon preferentially leaves the surface due to sublimation, and the carbon left behind self assembles into graphene. High-quality graphene can readily be produced on the Si face [the (0001) surface] in this manner, but graphene formation on the C-face [the (0001) surface] is more problematic. On the Si-face a well known intermediate layer forms between the SiC and the graphene; this so-called "buffer layer" likely aids in the formation of the graphene, but it is also thought to possibly reduce the mobility of electrons in the graphene. Hence, it is desired to produce graphene on the C-face (where a similar type of intermediate layer is not present). In addition to the formation of graphene in vacuum, an inert gas environment consisting of 1 atm argon has been studied as a means of allowing independent control of the sample temperature and the Si sublimation rate. Formation of very large, uniform graphene monolayers on the Si-face has been achieved. But again, the formation of such layers on the C-face is problematic, with unintentional oxidation of the surface found to be one limiting factor. Experiments are underway utilizing other environments, such as cryogenically-pumped neon (for improved purity) or ≈10-5 Torr of disilane, in an effort to improve the graphene quality on the C-face. Using a combination of low-energy electron microscopy (LEEM) and atomic force microscopy (AFM), the morphology of graphene on these surfaces of SiC has been studied in detail.

III. Device Concepts & Sensor/System Functionality

Thursday Sept 1	Location: Main Hall
Session III-B1	NANO-MECHANICAL BASED TECHNIQUES
	Chair: Greg Recine, Fordham University
10:45-11:10	OPTIMIZED DEPOSITION OF COLUMNAR THIN FILMS FOR VISUALIZATION OF LATENT FINGERPRINTS
Invited	Sarah Muhlberger, Pennsylvania State University
11:10-11:30	MULTIPLEXED RECONFIGURABLE BIOMARKER DETECTION IN THERMAL SPACE USING SOLID-LIQUID PHASE CHANGE NANOPARTICLES
	Ming Su, University of Central Florida
11:30-11:50	APPLICABILITY OF NANOMECHANICAL IMPRINTS IN ORAL CANCER DETECTION: DIFFERENTIATION FROM NORMAL TISSUES
	Vandana Tewari, Ram Manohar Lohia Institute of Medical Sciences-India
11:50-12:10	HYBRID FIRST-PRINCIPLE/MOLECULAR MECHANICAL STUDY OF BIOTIN-STREPTAVIDIN COMPLEX
	Alexei Bykhovski, North Carolina State University
12:10-12:35	NANOMAGNETS BASED SIMULTANEOUS DETECTION AND ISOLATION OFCHEMICAL AND BIOLOGICAL WARFARE AGENTS
Invited	Avinash Pandey, University of Allahabad, India
12:35	END OF CONFERENCE

III-B1. Nano-mechanical Based Techniques

OPTIMIZED DEPOSITION OF COLUMNAR THIN FILMS FOR VISUALIZATION OF LATENT FINGERPRINTS

Sarah Muhlberger, Drew Pulsifer, Akhlesh Lakhtakia, Robert Shaler
Pennsylvania State University

The majority of on-scene and in-laboratory fingerprint development techniques rely on physical or chemical interactions of the latent fingerprint residue with the development media. Our research focuses on replicating the texture or topology of the residue that is left behind, particularly in situations where the present methodology is either not ideal or inapplicable. Solid-state acquisition of fingerprint topology is achieved through the deposition of nanoscale columns assembled as a thin film under vacuum conditions onto the fingerprint residue and the underlying substrate. Ongoing research involves the application of the optimal development parameters to forensically relevant substrates, for which traditional development techniques are either not ideal or inapplicable. Substrates such as brass, stainless steel, various plastics and woods, and adhesive tapes are being examined. Additional evaporant materials such as gold, germanium oxide, nickel, and magnesium fluoride are being employed on each substrate in order to determine optimal development conditions for differing substrates. Split fingerprints are being utilized in order to compare the CTF development to traditional development techniques to assess any advantages provided by our nanoscale technology.

MULTIPLEXED RECONFIGURABLE BIOMARKER DETECTION IN THERMAL SPACE USING SOLID-LIQUID PHASE CHANGE NANOPARTICLES

Ming Su, Chaoming Wang, Liyuan Ma
University of Central Florida

We have developed a multiplexed reconfigurable method to detect biomarkers using solid-liquid phase change nanoparticles. This new signal transduction method uses a previously-unexplored thermal property of solid materials to readout binding events of biomarkers: the temperature of a solid does not rise above its melting point until the entire solid is molten, and the solid will have sharp melting peak in thermal analysis using differential scanning calorimetry (DSC). The solid materials are either pure metals or eutectic alloys of selected metals, and will be made into nanoparticles using colloid method. A one-to-one correspondence can be created between one type of biomarker and one type of nanoparticle. The biomarker identification is converted into detection of solid to liquid phase transitions of according nanoparticles, where the sharp melting peaks, large thermal scan range, and wide choice of nanoparticles enable high level of multiplicity and sensitivity. By combining plentiful phase diagram knowledge gained in the past hundreds years with size advantage of nanoparticles, thermal biosensing has shown several distinct features for

biomarker detection: (1) high multiplicity owing to sharp melting peaks, large thermal scan range, and rich materials choice; (2) high sensitivity due to large latent heats of fusion of selected materials, and controlled grafting density of ligand at nanoparticles; (3) wide detection range for multiple biomarkers whose concentrations differ few orders of magnitude by adjusting grafting density of ligands; (4) simultaneous detections of multiple DNA and protein biomarkers contained in complex fluids with minimal sample preparation; (5) thermal barcodes with ultrahigh labeling capacity can also be generated; and (6) statistically-significant number of detection results for pattern recognition-based pathogen discrimination. By filling knowledge gap among biosensing, metallurgy and nanotechnology, the thermal biosensing using solid-liquid phase transitions of nanoparticles represents a paradigm shift from existing electric, electronic, magnetic, or photonic systems, and will bring new capabilities for bio-defense applications.

APPLICABILITY OF NANOMECHANICAL IMPRINTS IN ORAL CANCER DETECTION: DIFFERENTIATION FROM NORMAL TISSUES

Vandana Tewari, Prashant K Sharma, Nuzhat Husain, Avinash C Pandey
Ram Manohar Lohia Institute of Medical Sciences-India, University of Allahabad-India

Nanoindentation has enabled research focused on quantitative determinations of mechanical properties and has recently emerged as a prevailing tool for measuring nano and microscale mechanical properties in tissues and other biomaterials. We report, for the first time, a comparison of the nanoindentation properties and nanoscale deformation mechanisms in surgically removed tissues of oral squamous cell carcinoma patients. Tissues are exigent group of materials as they are composed of hierarchical structures with key features down to the nanometer or micrometer scale. A technique that can probe mechanical properties at these scales a have a prospective in tackling questions related to cancer diagnosis and tumor progression. This technique investigates variations in mechanical properties with changes in tissue organization or composition in mineralized and soft tissues, and map mechanical properties spatially in complex biomaterials. Continuing advancements in indentation data analysis will increase the method's utility in the characterization of biomaterials.

HYBRID FIRST-PRINCIPLE/MOLECULAR MECHANICAL STUDY OF BIOTIN-STREPTAVIDIN COMPLEX

Alexei Bykhovski, Dwight Woolard
North Carolina State University, U.S. Army Research Office

Conformation, dynamics, THz-to-IR light absorption spectra and electronic transitions in biotin-streptavidin complex are simulated using a hybrid density functional theory/molecular mechanical approach. The self-assembly of novel biological architectures for use in long wavelength spectral sensing application will require the incorporation of active molecules into nanoscaffolds which will in turn be used to create the larger molecular matrices and supramolecular assemblies. These installation procedures for incorporating the functional polymeric components (e.g., stilbene-DNA bio-molecular switches) will require the use of other linker molecules such as biotin-streptavidin to facilitate the molecular construction. Hence, it will be very important to understand the dynamics of these individual molecular components and their subsequent influence on the larger nanostructures. Biotin-streptavidin is an example of an exceptionally stable non-covalent complex that finds many uses in bio-chemical sensing applications. The characterization of biotin is especially important since it is known to be flexible and optically active that therefore could strongly influence the functionality of the molecular switches to be used in DNA-based nanostructures, for example, in DNA-Origami. Therefore, it is very important to understand the fundamental dynamics of molecular compounds that contain biotin.

NANOMAGNETS BASED SIMULTANEOUS DETECTION AND ISOLATION OFCHEMICAL AND BIOLOGICAL WARFARE AGENTS

Avinash Pandey, Vyom Parashar
University of Allahabad, India

Chemical and biological weapons are capable of use across a wide spectrum of warfare, from acts of assassination and small-scale terrorism to various tactical and operational situations, both defensive and offensive, including strategic population attacks. In such situation of crisis any nation would require technology which can give the fast indication of such attacks so as to make fast decision on national security management. Here we describe two approaches based on nanomagnets to simultaneous detection and isolation of chemical and biological warfare agents. In first approach sulfur containing compounds especially thiols and disulphide can be targeted. The method uses a Gd(OH)3 nanosheets– sodium pentacyanonitrosylferrate(II) paramagnetic complex which produce an intermediate chromophore when coupled with a sulfur containing analyte, which is detectable with the naked eye and simultaneously can be removed by applying an external magnetic field. In second approach we synthesized dextrose capped GdS nanoparticles to explore the possibility of pathogen capture using these nanoparticles. It is known that many bacteria use mammalian cell surface carbohydrates as anchors for attachments, which subsequently results in infection. The unique combination of GdS and dextrose prompts us to embark on a pathogen detection. Herein, the GdSdextrose system not only detects Staphylococcus aureus within 5 min, but also removes up to 80% of the target bacteria from the medium.

III. Device Concepts & Sensor/System Functionality

Thursday Sept 1	Location: Room 215
Session III-A2	BIO-NANO SENSORS
	Chair: Lan Yang, Washington University
10:45-11:10	BIONANOELECTRONICS WITH NANOWIRES AND NANOTUBES
Invited	Aleksandr Noy, University of California-Merced
11:10-11:30	STRONG THZ SIGNATURES FROM NUCLEIC-ACID BIOMOLECULES IN NANOCHANNELS UNDER ELECTROPHORETIC CONTROL
	Elliott Brown, Physical Domains, LLC
11:30-11:50	NANOSTRUCTURED THIN FILM TRANSISTOR CIRCUIT AND SENSOR SKIN APPLIQUES
	Richard Claus, NanoSonic, Inc.
11:50-12:10	A PIXEL-FREE IMAGING SENSOR USING STIMULI-RESPONSIVE THERMOCHROMIC POLYMERS
	Anderson Chen, Stevens Institute of Technology
12:10-12:30	TRANSITION EDGE SENSOR BASED ON METAL-INSULATOR TRANSITION IN VO2 NANOWIRE
	Andrei Kolmakov, Southern Illinois University-Carbondale
12:30	END OF CONFERENCE

III-A2. Bio-Nano Sensors

BIONANOELECTRONICS WITH NANOWIRES AND NANOTUBES
Aleksandr Noy
University of California-Merced

Biological molecules perform sophisticated functions in living systems with complexity often far exceeding most of man-made devices and objects. Direct integration of biological components with electronic circuits could drastically increase their efficiency, complexity, and capabilities and result in novel sensing and signaling architectures. Yet, one of the obstacles for this vision of a bionanoelectronic circuit is the absence of a versatile interface that facilitates communication between biomolecules and electronic materials. We have been working on building a platform that integrates membrane proteins with one-dimensional inorganic materials such as silicon nanowires. In our devices, a nanotube of nanowire is covered by a lipid bilayer that serves both as a universal membrane protein matrix and an insulating shield. I will discuss the fabrication and properties of these “shielded” nanowires and their use in bionanoelectronic transistors that incorporate functional ion channels and ion pumps.

STRONG THZ SIGNATURES FROM NUCLEIC-ACID BIOMOLECULES IN NANOCHANNELS UNDER ELECTROPHORETIC CONTROL
Elliott Brown, Edgar Mendoza, Y. Kuznetsova, Steven Brueck
Physical Domains, LLC, Wright State University, Redondo Optics, Inc.,
University of New Mexico

Biomolecules have long been of interest for their low-lying vibrational modes which can resonate even below 1 THz. Of particular interest are nucleic acids because of the potential to do genetic finger-printing, virus detection, etc. based on strong interaction of DNA and RNA with THz radiation. Two difficulties in realizing these capabilities are the strong damping of the vibrations with in-vivo DNA or RNA, and in making the oscillator strength large enough to be detectable with the strong THz attenuation of any physiological environment. We have tackled both difficulties with a nanofluidic technology based on submicron fabrication of enclosed channels in SiO2. Along with the application of phosphate-based buffer solutions, this has produced surprisingly strong (absorbance ~0.8) and narrow (<20 GHz) signatures in the 800-GHz-to-1.0-THz region.

NANOSTRUCTURED THIN FILM TRANSISTOR CIRCUIT AND SENSOR SKIN APPLIQUES

Yuhong Kang, Hang Ruan, Keith Hill, Brian Leslie, Amanda Dippold, Andrea Hill, Joseph Schetz, Richard Claus
NanoSonic Inc., Virginia Institute of Technology

This paper discusses nanostructured thin film applique sensors and nanostructured semiconductor device circuits for the measurement and mapping of normal and tangential stresses due to air and water flow across structural surfaces. We have fabricated and experimentally evaluated the performance of both mechanical sensor elements and thin film transistor arrays that allow data from arrays of such elements to be read out in row and column data format. The sensors take advantage of the properties of novel electrically conducting piezoresistive elastomers fabricated by incorporating controlled volume percentages of metal nanoclusters in a polymer matrix. The molecular-level layer-by-layer self-assembly process used to synthesize the elastomeric nanocomposites allows control over the stress-to-resistance transfer function as well as its degree of anisotropy. These properties may be spatially patterned in the plane of two-dimensional thin films to create individual sensor elements as well as electrically connected multi-sensor arrays. Such sensors and sensor arrays have been evaluated in the laboratory, calibrated using known flow conditions, and tested through water tunnel tests, wind tunnel tests from subsonic through hypersonic flows, and on free-flight RC aircraft test models. Sensor design, fabrication, calibration, testing, and use on several flow measurement problems are discussed. Sequential external addressing of the rows and columns allows the construction of a map of sensor data over the two-dimensional extent of the array. The several kilohertz frequency response of the sensor elements determines the maximum practical data acquisition and refresh rate of the total sensor data map. Addressable sensor and TFT circuitry arrays as large as 64x64 elements have been demonstrated.

A PIXEL-FREE IMAGING SENSOR USING STIMULI-RESPONSIVE THERMOCHROMIC POLYMERS

Anderson Chen, Chao Wang, Gang Chen, Seong-Wook Park, Rainer Martini, Clyde Bethea
Stevens Institute of Technology, Quantum Technology Consultants, Inc.

Micro-bolometric systems will eventually break the mega-pixel barrier as the art of micro-fabrication finds ingenious ways to push towards a new level of finesse. However, to improve upon the sensitivity of these devices, the challenge is to build micron sized bi-metallic optical cantilever structures, which adds an additional degree of complexity to its “current” counterpart. On the other hand, stimuli-responsive polymers have experienced rapid growth and interest in the past two decades. In particular, thermochromic polymers, which are molecular sized detectors that changes color as a function of temperature, have found many contact style thermographic applications in both commercial and research applications. On the other hand, they can also be used in a process coined “wavelength transformation” whereby photo-induced heat is converted into a visible spectrum signal. In this talk, we will present a highly versatile room temperature imaging sensor that is both pixel free and has spectrally broad sensitivity using thermochromic liquid crystals (TLCs). With this single room temperature sensor, we have applied it towards megapixel imaging of a hand at ambient background temperature as well as emission mode imaging of a variety of high radiant sources. From the acquired images, the scene derived NEDT at 1 megapixel and at comparable resolutions to current pyro-optical MEMS cantilever sensors will be presented.

TRANSITION EDGE SENSOR BASED ON METAL-INSULATOR TRANSITION IN VO2 NANOWIRE

Andrei Kolmakov
Southern Illinois University-Carbondale

The two main factors, which define the performance of sensors, are their receptor and transduction functions. The first defines the interaction of the ambient agent (gas molecules, photons etc) with the sensing element: its rate, selectivity and reversibility. The second is the mechanism of conversion of this interaction into the output signal. Extreme sharpness and stability of the reversible metal-insulator phase transition in VO2 nanowires represent the prospective sensing platform. The application of the aforementioned principle recently led to realization of inexpensive and yet excellently performing real world sensing devices which combine ultra-small size and power consumption with great sensitivity.

IV. Materials, Fabrication and Integration for Sensor/System Architectures

Thursday Sept 1	Location: Room 474
Session IV-A1	ENGINEERED NANOPARTICLES FOR GAS SENSING DEVICES
	Chair: Joseph Slocik, U.S. Air Force Research Laboratory, Wright Patterson
10:45-11:10	NANOCLUSTER DESIGN FOR HIGH SENSITIVITY/SELECTIVITY CHEMORESISTIVE SENSING
	Mario Ancona, U.S. Naval Research Laboratory
11:10-11:30	FUNCTIONALISED NANODIAMOND LAYERS AS HIGH AFFINITY TUNEABLE SENSITIVE COATINGS FOR ULTRATRACE GAS DETECTION
	Benoit Tard, CEA-France
11:30-11:50	TOWARDS ONE KEY TO ONE LOCK: HIGHLY SENSITIVE AND SELECTIVE GAS SENSOR BASED ON SURFACE MODIFIED INDIUM OXIDE NANOPARTICLE FILM
	Kun Yao, University of New Orleans
11:50-12:10	PREDICTING PROPERTIES OF NANOCOMPOSITES FOR ENHANCING SECURITY SENSORY DEVICES
	Jerry Houser, AlphaSTAR Corporation
12:10-12:30	PLASMONIC BIOCHEMICAL SENSOR BASED ON ANISOTROPIC EXTINCTION OF LIGHT BY ARRAYS OF GOLD NANOCYLINDERS
	Anatoily Pinchuk, University of Colorado-Colorado Springs
12:30	END OF CONFERENCE

IV-A1. Engineered Nanoparticles for Gas Sensing Devices

NANOCLUSTER DESIGN FOR HIGH SENSITIVITY/SELECTIVITY CHEMORESISTIVE SENSING

Mario Ancona, Arthur Snow, Keith Perkins
U.S. Naval Research Laboratory-Washington, DC

Films of chemically functionalized gold nanoclusters form the basis of an important class of chemiresistors known as MIME sensors. The central element of such sensors is the gold nanocluster that is a few nanometers in diameter and consists of a gold core surrounded by a monolayer of stabilizing ligands. When deposited on an insulating surface, a film of such nanoclusters can be electrically conducting by way of electron tunneling between the cluster cores. Transduction occurs when vapor analyte molecules diffuse into the film, modulate the tunneling process, and are thereby detected via a change in the film's resistance. The ligand shell is crucial in the design as it both stabilizes the nanocluster and imparts sensitivity/selectivity through its interaction with the analyte. In this contribution we discuss the characteristics of MIME sensors in which the ligand shell is chosen to build in a specific chemical affinity for the analyte of interest. In particular, we employ nanoclusters with carboxylterminated ligands that interact strongly with amines or other analytes that form hydrogen bonds. As we discuss, this built-in chemical functionality does indeed bring very high sensitivity (<1ppb) and strong selectivity, however, these attributes come at the expense of response time.

FUNCTIONALISED NANODIAMOND LAYERS AS HIGH AFFINITY TUNEABLE SENSITIVE COATINGS FOR ULTRATRACE GAS DETECTION

B. Tard, E. Scorsone, H. Girard, P. Bergonzo
CEA-France

NanoDiamonds (NDs) have been deposited as homogeneous layers on a variety of substrates thus offering a highly stable sp3 carbon porous matrix. The stability of the particles combined with the carbon terminated surface offers wide opportunities for surface modification through a wide range of plasma treatments or organic functionalisation. A number of chemical or biological receptors have been grafted on diamond surfaces using various routes derived from standard organic chemistry. This modification of the surface may be used smartly to tune the possible interactions of the surface with the gas species to be sensed. In particular the highly versatile, stable and porous nature of the matrix is promising for the development of sensitive coatings for chemical detection in the gas phase, especially when combined with gravimetric transducers. We have processed commercially available NDs: after size purification by centrifugation, they were

characterised using DLL and SEM imaging, prior to be deposited as highly uniform porous coatings of controlled thicknesses in the range of a few tens of nm.

TOWARDS ONE KEY TO ONE LOCK: HIGHLY SENSITIVE AND SELECTIVE GAS SENSOR BASED ON SURFACE MODIFIED INDIUM OXIDE NANOPARTICLE FILM

Kun Yao, Daniela Caruntu, Charles O'Connor, Weilie Zhou
University of New Orleans

In_2O_3 nanoparticles synthesized via wet chemistry method were assembled and further patterned into sensor arrays for gas detection. By engineering the surface modification using different noble metals, both sensitivity and selectivity were enormously improved. The size influence of different metal modifier was then investigated and sensor fabrication on flexile substrate was also explored. Metal-oxide nanostructures have been widely studied for highly sensitive detections in different chemical environments. Homogenous In_2O_3 nanoparticles (NPs) with diameters in the range of 7~10 nm were synthesized via a chemical solution method and well assembled on Si substrate for gas detection. Based on our previous work on tuning different parameters of NP based sensors, surface modification was found to play the most important role in enhancing the sensitivity. In this work, sensor arrays were further fabricated on such NP film on one chip and modified with different noble metals of Au, Pd and Pt, respectively, showing clearly responses when exposed to several target gases. Besides the highly enhanced sensitivity, such sensor array demonstrated a good selectivity like one key to one lock, which implied that such perfect selectivity was possibly to be realized in a certain condition. The fabrication of such highly sensitive and selective sensor on flexible substrates was also explored.

PREDICTING PROPERTIES OF NANOCOMPOSITES FOR ENHANCING SECURITY SENSORY DEVICES

Frank Abdi, Mohit Garg, Jerry Housner
AlphaSTAR Corporation-CA

Nanocomposite materials are commonly being employed to develop highly reliable sensory devices that find application in security systems such as thin nanocomposite film sensors and nanocomposite coatings for optical sensor. Design of these devices requires determination of the physical properties of the nanocomposite as a function of its constituents. It is also important to know the sensitivity of the physical properties of the nanocomposite to the properties of the nanocomposite constituents as these constituent properties can be thought of as design variables of the nanocomposite and provide insight on which variables need to be controlled in achieving the desired objectives for the sensory devices. The objective of the paper is to focus on prediction and test validation of the behavior of advanced multi-scale nanocomposites containing nano particles of different shapes (e.g., spherical, platelet and chopped fiber) in polymeric, ceramic, and metallic materials. Prediction capability covers delamination, fracture toughness, impact resistance, conductivity and fire resistance of the resulting nanocomposite. The methodology uses a high fidelity procedure that utilizes: 1) molecular dynamics to predict nanocomposite bulk properties; 2) constituent material characterization/qualification to predict the effect of interfacial strength on nanocomposite strength, stiffness, and conductivity; 3) durability and damage tolerance by multi-scale, multi-physics progressive failure and finite element analysis for simulation of carbon nanotubes (CNT); and 4) probabilistic methods to examine effects of variation in CNT aspect ratio, waviness, voids, fiber volume ratio of CNT, interface and matrix strength. The proposed paper demonstrates good correlation between simulation and experimental data.

PLASMONIC BIOCHEMICAL SENSOR BASED ON ANISOTROPIC EXTINCTION OF LIGHT BY ARRAYS OF GOLD NANOCYLINDERS

Anatoliy Pinchuk, Vira Kravets, Victor Gozhenko, Oleg Yeshchenko
University of Colorado-Colorado Springs, National Taras Shevchenko Kyiv University-Ukraine

We report the experimental results on our recently proposed concept of a plasmonic biochemical sensor based on electrodynamic coupling between gold nanocylinders regularly arranged on a substrate. The far-field experimental optical extinction spectra of linear chains of gold nanocylinders with interparticle separations close to the particles' surface plasmon resonance (SPR) wavelength λ_{SPR} reveal anisotropic and non-monotonic shift of the SPR peak position with increase of the distance d. The shift of the $\lambda_{SPR}(d)$ can be used to transduce the binding of an analyte molecule to a gold nanocylinder.

IV. Materials, Fabrication and Integration for Sensor/System Architectures

Thursday Sept 1	Location: Room 475
Session IV-S1	GRAPHENE DEVICE FABRICATION & OPTIMIZATION
	Chair: Amal Kasry, Egypt Nanotechnology Center & IBM T.J. Watson Research Center
10:45-11:10	PATTERNING SEMICONDUCTIVE GRAPHENE NANOSTRUCTURES THROUGH THE SELF-ASSEMBLED TEMPLATES
	Alexander Sinitskii, University of Nebraska-Lincoln
11:10-11:30	FABRICATION OF SEMICONDUCTING NANOPERFORATED GRAPHENE USING BLOCK COPOLYMER LITHOGRAPHY
	Myungwoong Kim, University of Wisconsin-Madison
11:30-11:50	PHOTO-INDUCED EFFECTS IN GRAPHENE CHANNELS INTERFACED WITH QUANTUM DOTS IN FIELD EFFECT TRANSISTORS
	Samarth Trivedi, New Jersey Institute of Technology
11:50-12:10	NANOWIRE-GRAPHENE ELECTRODE HYBRID DEVICES
	Yo-Rhin Rhim, Johns Hopkins University
12:10-12:30	MODELING GRAPHENE NANOELECTRONICS: AN HISTORICAL PERSPECTIVE
	Jean-Pierre Leburton, University of Illinois at Urbana-Champaign
12:30	END OF CONFERENCE

IV-S1. Graphene Device Fabrication & Optimization

PATTERNING SEMICONDUCTIVE GRAPHENE NANOSTRUCTURES THROUGH THE SELF-ASSEMBLED TEMPLATES
Alexander Sinitskii, James Tour
University of Nebraska-Lincoln, Rice University

Recently, there has been considerable interest in graphene nanostructures with feature sizes less than 10 nm since they were theoretically and experimentally shown to have electronic band gaps large enough for room temperature transistor operation. Such graphene nanostructures include quantum dots, nanoribbons (GNRs) and nanomeshes (GNMs). Since patterning with sub-10-nm resolution by electron beam lithography is still quite challenging and requires state-of-the-art experimental facilities, alternative techniques for making graphene nanostructures are being developed. In this work we demonstrate that colloidal particles, metal oxide nanowires and assemblies of thereof can serve as easily accessible and inexpensive masks for patterning GNMs and arrays of GNRs. Semiconductive graphene nanostructures fabricated in this work exhibit promising electronic properties including high ON-OFF ratios and ON-state conductivities.

FABRICATION OF SEMICONDUCTING NANOPERFORATED GRAPHENE USING BLOCK COPOLYMER LITHOGRAPHY
Padma Gopalan, Myungwoong Kim, Nathaniel Safron, Michael Arnold
University of Wisconsin-Madison

Compared to current materials, graphene conducts electrical charges extraordinarily fast,potentially 100-1000x times faster than silicon and 20,000-100,000x faster than state-of-the-art flexible semiconducting materials. Unaltered, intrinsic graphene is not semiconducting which prevents the modulation or “switching” of its electrical conductance – the basis for the operation of transistors for digital logic, semiconductor-based optoelectronic devices, and semiconductor-based sensors. To address this problem, it has been shown that quantum confinement effects can be used to open up a band gap in graphene. It has been demonstrated that the band gap of graphene nanoribbons, *Eg*, patterned using electron-beam lithography, roughly varies inversely with the width of the nanoribbons, *w*, according to $Eg \sim 0.2\text{-}1.5\ \text{eV}\cdot\text{nm}/w$. In this work, we demonstrate an approach for nanopatterning graphene using block copolymer (BCP) lithography that addresses both the resolution and scalability challenges. The result is a nanoperforated graphene with sub-10 nm constriction width which is semiconducting. Nanoperforated graphene could be an ideal material for semiconductor sensors because of the ultrahigh edge density that can be functionalized. Graphene is atomically thin; hence the sensitivity of the sensors based on graphene will be especially high.

PHOTO-INDUCED EFFECTS IN GRAPHENE CHANNELS INTERFACED WITH QUANTUM DOTS IN FIELD EFFECT TRANSISTORS

Samarth Trivedi, Haim Grebel
New Jersey Institute of Technology

Field effect element with graphene channel was interfaced with quantum dot (QD) array. The electrical characteristics, as well as its opto-electronic behaviour were assessed. Negative differential resistance (NDR) was observed as a function of drain-source potential. The photoluminescence of the QDs was affected by both the drain-source and gate potentials and was correlated with the appearance of NDR. Graphene is a mono layer thick, two dimensional crystal of carbon atoms, which are densely packed into a benzene ring structure. Graphene portrays high conductivity, chemical inertness, mechanical robustness and unusual dispersion relations. Characteristics of free-standing, mono or bi-layer graphene have been studied when deposited over nano-pore array of anodized aluminum oxide (AAO) substrate. One may postulate that the periodic array of pores will have a profound effect on the photoluminescence of chromophores or QDs imbedded in them. Such arrangement led to therealization of the first visible surface plasmon laser. Negative differential resistance (NDR) is a nonlinear electronic response as a result of a competition between tunneling and thermal processes. Here we explore NDR for graphene channels when interfaced with quantum semiconductor dots.

NANOWIRE-GRAPHENE ELECTRODE HYBRID DEVICES

Yo-Rhin Rhim, Andrew Monica, Joan Hoffmann, Elisabeth Smela, Robert Osiander
Johns Hopkins University, University of Maryland-College Park

Developing cost-effective devices for renewable energy has remained a challenge. Graphene has recently attracted attention for use as a transparent electrode, replacing ITO because of its flexibility and lower cost. Incorporation of graphene electrodes into solar energy conversion devices is expected to improve performance by allowing a greater amount of the incident light to reach the semiconductor. This research therefore focuses on developing large-area graphene optoelectronic devices with sufficient power output and efficiency by developing techniques for assembly and testing protocols. We aim to improve the scalability and cost-effectiveness, as well as address characterization challenges associated with transferring graphene onto semiconducting nanowires for the development of nanowire-graphene hybrid devices. Chemical vapor deposition (CVD) has been used successfully to grow uniform, large areas of graphene with sheet resistivity values on the order of 100 Ω/sq. For the hybrid nanowire devices, continuous large-area graphene was grown via CVD onto thin copper films and transferred onto insulating substrates. Raman spectroscopy, AFM, and optical characterization revealed the transferred areas to be 3-4 layers thick with 90-95% areal coverage. Two main methods of graphene transfer and nanowire array incorporation were investigated.

MODELING GRAPHENE NANOELECTRONICS: AN HISTORICAL PERSPECTIVE

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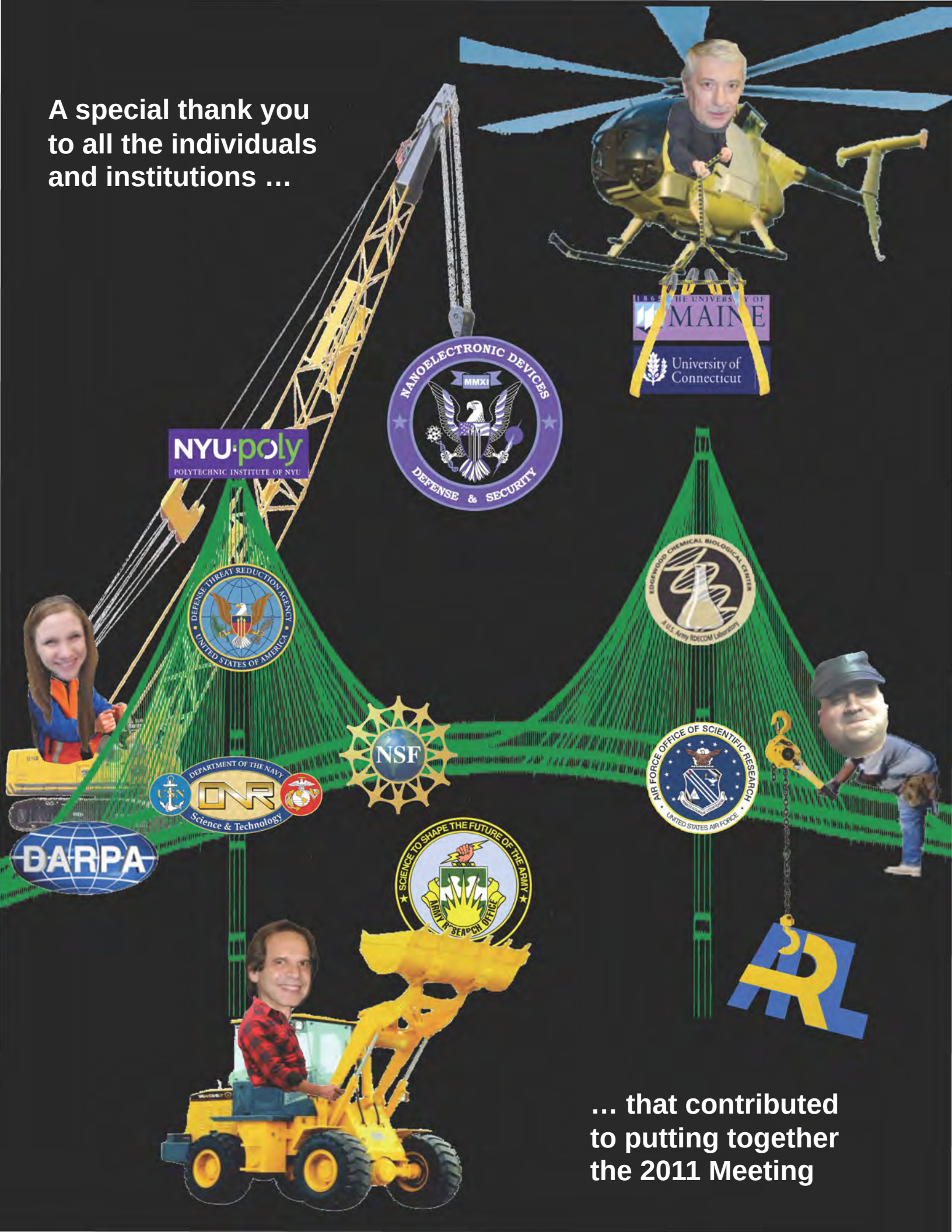
In this talk, we will address basic issues related to non-linear transport in G-FETs. Specifically, we will discuss the concept of saturation velocity in G-FETs, and its interpretations reminiscent of MOSFET modeling in the early days. We use an approach based on self-consistent solution of the Boltzmann transport equation in the high field regime within the device geometries, and its boundary conditions. We obtain the output and transfer characteristics of G-FETs by using the charge-control model for the current, and found good agreement with the experimental data of Meric et al. Recently, graphene field-effect transistors (GFETs) were fabricated and exhibited *I-V* characteristics similar to conventional silicon MOS transistors. Low field mobilities were however strongly degraded by the presence of coulomb space charge in the neighboring oxides, whereas nonlinearities in the current-voltage characteristics were interpreted as caused by carrier velocity saturation for which the value would depend on the carrier concentration induced by gate voltages in the 2D graphene mono-layer.

Notes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